MYCOLOGIA

OFFICIAL ORGAN OF THE MYCOLOGICAL SOCIETY OF AMERICA

VOL. XXXIV JANUARY–FEBRUARY, 1942 NO. 1

GEORGIA PYRENOMYCETES III

J. H. MILLER AND GWENDOLYN BURTON

(WITH 9 FIGURES)

There is a large series of Ascomycetes occurring on dead herbaceous stems during their second summer, and with the exception of *Diaporthe Arctii* (Lasch) Nits., these fall for the most part within the genera *Leptosphaeria, Metasphaeria,* and *Ophiobolus.* In the fall and winter following the growing season these stems show a variety of conidial stages, but their relationship with the perfect forms has been worked out only in a very few cases.

Host specificity is seldom found. Many, however, behave as *Ophiobolus anguillides* (Cooke) Sacc. on *Ambrosia artemisiifolia* L.; that is, during July and August it can be found on practically every stem and only rarely on other Compositae.

The so-called perithecia in this group are in reality uniloculate stromata with thick pseudoparenchymatous walls, and asci are embedded in vertically placed paraphysoids connected to the upper wall as well as the base. This is typical of the Pseudosphaeriales order.

The following constitute part of a group that are apparently new to American literature. The rest will follow in later papers.

The types are deposited in the University of Georgia herbarium.

1. **Leptosphaeria clavispora** sp. nov. (FIGS. 1–2)

Perithecia scattered, sometimes gregarious, innate, partially erumpent, depressed-globose, black, with slightly papillate ostiola,

[MYCOLOGIA for November–December (**33**: 579–717) was issued December 1, 1941]

250–500 μ in diam.; asci arising from base of perithecium, broadly clavate, with thickened apical wall, with very short stalk, immersed in connected paraphysoids, 98–119 × 13–14 μ; ascospores 8, biseriate to inordinate, oblong-clavate, straight to slightly curved, with upper end rounded and lower end tapering to a point, 6–10 septate, constricted, light olive brown to dark brown, 48–51 × 8–9 μ.

Perithecia sparsa, interdum gregaria, innata, partim erumpentia, depresso-globosa, nigra, ostiolo leniter papillato, 250–500 μ in diam.; asci ex basi perithecii enati, crasso-clavata, membrana apicibus incrassatis, valde breviter stipitati, in connexis paraphysoidibus immersi, 98–119 × 13–14 μ; ascosporae 8, biseriatae vel inordinatae, oblongo-clavatae, rectae vel leniter curvatae, vertice rotundatae et posto attenuatae, 6–10 septatae, constrictae, dilute olivaceo-brunneolae vel atro-brunneae, 48–51 × 8–9 μ.

On dead stems of *Eupatorium capillifolium* (Lam.) Small. Campus, University of Georgia, July 1940.

Leptosphaeria clavigera (Cooke & Ellis) Sacc. approaches this species in spore shape, but differs in the smaller spores—25–35 × 6–8 μ.

2. **Leptosphaeria longipedicellata** sp. nov. (FIG. 3)

Perithecia scattered, innate, becoming slightly erumpent, black, sub-conical, with papillate ostiola, with thick stromatic wall, 250–500 μ in diam.; asci broadly clavate, apically thickened, with long stipe, arising for the most part from the base of the perithecium, spore part 80–94 × 14–16 μ, stipe 34–58 × 4–6 μ, embedded in connected paraphysoids; ascospores 8, biseriate to inordinate, oblong-fusoid, straight to slightly curved, chiefly dark brown, 3 septate, constricted, 25–32 × 6–11.5 μ.

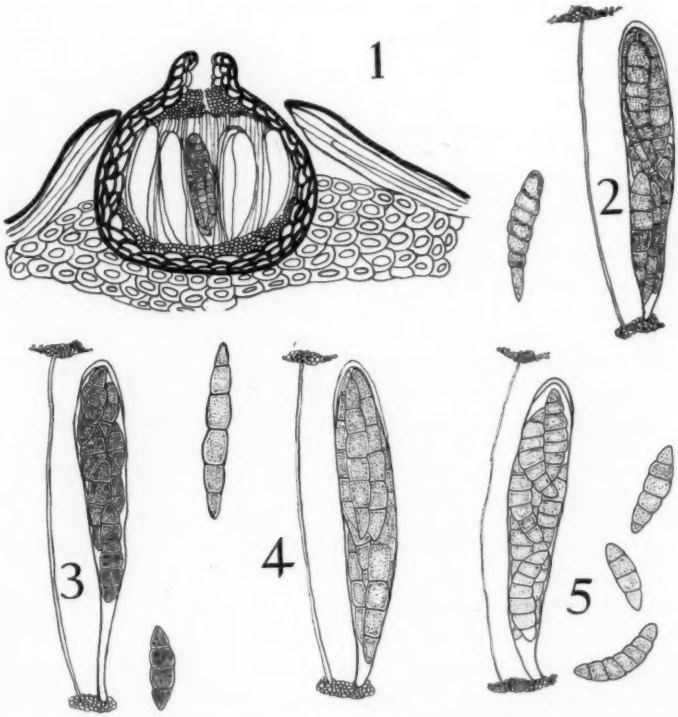
Perithecia sparsa, innata, partim erumpentia, nigra, sub-conica, ostiolo papillato, pariete crasso-stromatico, 250–500 μ in diam.; asci crasso clavati, apicis incrassatis, longe stipitati, plerumque ex basi peritheciis evoluti, spora parte 80–94 × 14–16 μ pedicello 34–58 × 4–6 μ, in connexis paraphysoidibus immersi; ascosporae 8, biseriatae vel inordinatae, oblongo-fusoidae, rectae vel lenite curvatae, admodum atro-brunnae, 3-septatae, constrictae, 25–32 × 6–11.5 μ.

On dead stems of herbaceous plants; *Daucus Carota* L., *Smallanthus Uvedalia* (L.) Mack., and *Solidago Caesia* L. Campus, University of Georgia, July through September 1939.

This species differs from the closely related *Leptosphaeria subconica* (Cooke & Peck) Sacc. and *L. vagabunda Sacc.* in possessing larger ascospores and in the long tapering stalk of the ascus. The latter character is rather rare in the genus.

3. **Leptosphaeria Asteris** sp. nov. (FIG. 4)

Perithecia scattered, innate, partially erumpent in lines, black, depressed-globose with slightly raised ostiola, 300–500 μ in diam., with very thick stromatic walls, especially at the base; asci widely clavate, with the wall especially thick at the apex, short stalk, aris-



FIGS. 1, 2, *Leptosphaeria clavispora;* 3, *L. longipedicellata;* 4, *L. Asteris;* 5, *L. subcompressa.*

ing from the base of the perithecium, immersed in vertical paraphysoids, 103–126 $\times$ 16 μ; ascospores 8, inordinate, elongate, cylindric-fusoid, straight, light brown to dark brown, 5 septate, slightly constricted at the cross walls, 65–90 $\times$ 8–9 μ.

Perithecia sparsa, innata, partim in lineis erumpentia, nigra, depresso-globosa, ostiolo leniter elevato, 300–500 μ in diam.; pariete stromatis admodum crasso, plerumque ad basim; asci lato-clavati, membrana apicalis forte in-

crassata, breviter stipitati, ex basi enati, in verticalibus paraphysoidibus immersi, 103–126 × 16 μ; ascosporae 8, inordinatae, elongatae, cylindrico-fusoidae, rectae, dilute olivaceo-brunneolae vel atro-brunneae, 5 septatae, leniter constrictae, 65–90 × 8–9 μ.

On dead stems of *Aster sagittifolius* Wed. v. *dissitiflorus* Berg. Campus, University of Georgia, April, 1939.

Leptosphaeria mesoedema (Berk. & Curt.) Ellis & Ev. is another large spored form on Compositae, but it differs in having a much enlarged central cell that is sometimes divided longitudinally.

4. **Leptosphaeria subcompressa** sp. nov. (FIG. 5)

Perithecia scattered or gregarious in longitudinal series, single or coalesced in a pseudo-stroma, innate, becoming partially erumpent, black, longitudinally compressed, sub-conical with slightly attenuated necks, with rounded ostiola, 250–500 μ in diam.; asci broadly clavate, apically thickened, with brief stipe, for the most part arising from the base of the perithecium, embedded in connected paraphysoids, 110–126 × 20.5 μ; ascospores 8, biseriate to inordinate, oblong-fusoid, straight to curved, when mature 5–7 septate, constricted, yellowish, 30–40 × 10–12 μ.

Perithecia sparsa vel gregaria in serie longitudinali deposita, singula vel in pseudostromata coalita, innata, partim erumpentia, nigra, longitudinae compressa, sub-conica, colli leniter attenuato, ostiolo rotundo, 250–500 μ in diam.; asci crasso-clavati, apicibus incrassatis breviter stipitati, plerumque ex basi perithecii evoluti, in connexis paraphysoidibus immersi, 110–126 × 20.5 μ; ascosporae 8, biseriatae vel inordinatae, oblongo-fusoidae, rectae vel curvatae, maturae 5–7 septatae, constrictae, flavidae, 30–40 × 10–12 μ.

On dead culms of *Andropogon glomeratus* (Walt.) BSP., Campus, University of Georgia, August 1941.

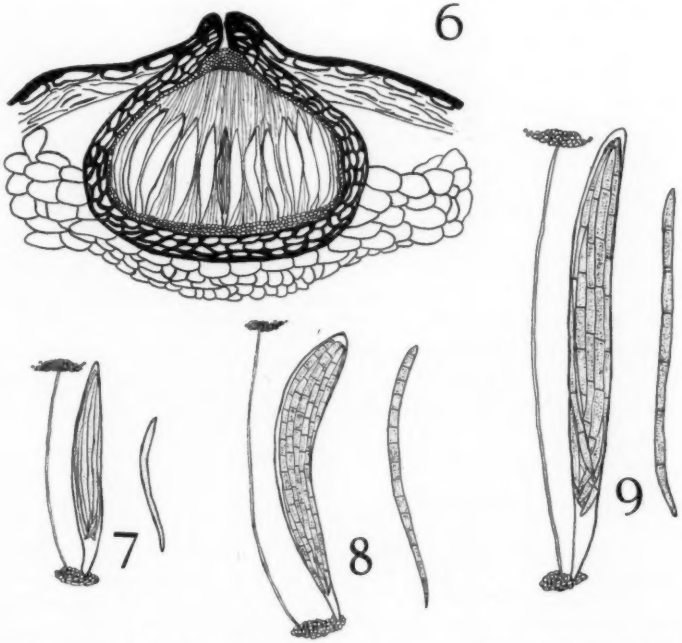
Other species reported on *Andropogon* all differ in possessing much smaller spores. The nearest approach is in *Leptosphaeria latebrosa* (Ellis.) Sacc. with spores 20–25 × 3 μ.

5. **Ophiobolus nigro-clypeata** sp. nov. (FIGS. 6–7)

Perithecia aggregated or scattered, depressed-globose, 350–800 μ in diam., innate, not erumpent, covered by black epidermis, which is pierced by a briefly papillate ostiolar neck, with thick pseudo-parenchymatous walls; asci arising from base and sides of perithecium, clavate-lanceolate, with short stipe, immersed in vertical paraphysoids, 57–70 × 7–11 μ; ascospores parallel to irregularly

fasciculate, filiform, not septate, curved when free, 45–65 × 3–4 μ, hyaline to light yellowish.

Perithecia aggregata vel sparsa, depresso-globosa, 350–800 μ in diam., innata, non-erumpentia, nigro epidermide tecta, ex quo ostiola breviter papillata erumpunt, pariete crasse pseudoparenchymato; asci inferne et lateraliter evoluti, clavato-lanceolati, breviter stipitati, in verticalis paraphysoidibus im-



FIGS. 6, 7, *Ophiobolus nigro-clypeata;* 8, *O. Junci;* 9, *O. Cirsii-altissimi.*

mersi, 57–70 × 7–11 μ; ascosporae parallelae vel fasciculatae irregulariter, filiformae, non septatae, emersae curvatae, hyalinae vel flavidae, 45–65 × 3–4 μ.

On dead stems of herbaceous plants; *Achillea Millefolium* L., *Ambrosia artemisiifolia* L., *Amsonia Tabernaemontana* Walt., *Cassia Chamaecrista* L., *Cimicifuga racemosa* (L.) Nutt., *Coreopsis major* Walt., *Coreopsis major* Walt. v. *Oemleri Britt.*, *Daucus Carota* L., *Desmodium canadense* (L.) DC., *Desmodium paniculatum* (L.) DC., v. *angustifolium* G. & T., *Firmiana platanifolia*

(L.) R.Br., *Helianthus microcephalus* G. & T., *Ligusticum canadense* (L.) Britt., *Oxypolis rigidior* (L.) Coult. & Rose, *Smilax laurifolia* L., *Solidago serotina* Ait. Clarke Co., Ga., July to Sept. 1939–1940.

At the end of the section on *Ophiobolus*, Ellis and Everhart (North American Pyrenomycetes, p. 398) cite this species under "Species imperfectly known." This is referred here to *Sphaeria Solidaginis* Fries or *Ophiobolus Solidaginis* Sacc. The writers have compared the Georgia form with the Ellis specimen and they are identical, but as Ellis did not know what Fries had in mind and as it is now impossible to determine his concept with any degree of certainty, it seems best to give this form a new name.

This species differs from all other forms in the genus in that it does not become even partially erumpent, and is always covered by a blackened epidermis that could be called a clypeus. When considered alone this character does not have much taxonomic value. As pointed out in previous papers the most important characters are those found within the perithecial centrum, and as in this case they are entirely those of the Pseudosphaeriales it appears logical to retain it in *Ophiobolus* rather than place it near *Linospora* or *Anthostomella*.

6. **Ophiobolus Cirsii-altissimi** sp. nov. (FIG. 8)

Perithecia scattered, innate, finally suberumpent, black, much depressed-globose, with short conic papillate ostiolar neck, with walls of perithecia stromatic and thick, 300–500 μ in diam.; asci 8-spored, cylindric-clavate, more or less curved, with thick apices, short stalked, arising chiefly from the base of the perithecium, 119–145 $\times$ 12–15 μ, immersed in connected paraphysoids; ascospores parallel, cylindrical, upper end rounded, lower chiefly somewhat attenuated, curved when free of ascus, many septate, not constricted, yellowish to dark brown, 92–136 $\times$ 5–6 μ.

Perithecia sparsa, innata, tandem suberumpentia, nigra, multo depresso-globosa, ostiolo breviter conoideo papillato, pariete perithecii crasso, stromato, 300–500 μ in diam.; asci octospori, cylindraceo-clavati plus minusve curvati, apicibus incrassatis, breviter stipitati, plerumque ex basi perithecii evoluti, 119–145 $\times$ 12–15 μ, in connexis paraphysoidibus immersi; ascosporae parallelae, cylindracae, antice rotundatae, postice plerumque paullo magis attenuatae, emersae curvatae, multiseptatae, non constrictae, flavidae vel atro-brunnae, 92–136 $\times$ 5–6 μ.

On dead stems of *Cirsium altissimum* (L.) Spreng. Campus, University of Georgia, July 1940.

This species differs from the other species reported on *Cirsium*, *Ophiobolus acuminatus* (Sow. ex Fries) Duby and *O. Cirsii* (Karst.) Sacc., in possessing much wider ascospores.

7. **Ophiobolus Junci** sp. nov. (FIG. 9)

Perithecia scattered, sometimes gregarious, innate, finally erumpent, black, subconical, with truncate papillate ostiolar necks, with thick stromatic walls, 300–800 μ in diam.; asci numerous, cylindric-clavate, with thick apical wall, short stalked, chiefly arising from base of perithecium, immersed in connected paraphysoids, 8-spored, 138–160 $\times$ 14–16 μ; ascospores chiefly parallel, cylindric-fusoid, slightly curved, nearly as long as the ascus, chiefly 6-septate, not constricted, yellowish to brown, 115–138 $\times$ 4–5 μ.

Perithecia sparsa, interdum gregaria, innata, tandem erumpentia, nigra, subconoidea, ostiolo papillato-truncato; pariete crasso, stromatico, 300–800 μ in diam.; asci numerosi, cylindraceo-clavati, membrano ad apicem incrassato, breviter stipitati, plerumque ex basi perithecii enati, in connexis paraphysoidibus immersi, octospori, 138–160 $\times$ 14–16 μ; ascosporae plerumque parallelae, cylindraceo-fusoidae, leniter curvatae, prope tam longae quam asci, plerumque 6 septatae, non constrictae, flavidae vel fuscae, 115–138 $\times$ 4–5 μ.

On dead stems of *Juncus effusus* L. Campus, University of Georgia, May 1940.

Ophiobolus juncicola Rehm differs in having spores 120–150 $\times$ 1 μ.

DEPARTMENT OF PLANT PATHOLOGY,
THE UNIVERSITY OF GEORGIA,
ATHENS, GEORGIA

EXPLANATION OF FIGURES

FIGS. 1–2, drawings of *Leptosphaeria clavispora*. (1, perithecium; 2, ascus and ascospore.); 3, *Leptosphaeria longipedicellata*, ascus and ascospore; 4, *Leptosphaeria Asteris*, ascus and ascospore; 5, *Leptosphaeria subcompressa*, ascus and ascospore.

FIGS. 6–7. *Ophiobolus nigro-clypeata*. (6, perithecium; 7, ascus and ascospore.); 8, *Ophiobolus Junci*, ascus and ascospore; 9, *Ophiobolus Cirsii-altissimi*, ascus and ascospore.

Drawings of asci and spores were made with the camera lucida with an approximate magnification of 365.

SPORE ORNAMENTATION OF SOME AMERICAN RUSSULAE AND A NEW SPECIES OF LACTARIA

GERTRUDE S. BURLINGHAM

(WITH 14 FIGURES)

The first eight figures accompanying this article show the spore ornamentation of *Russulae* described by the late C. H. Kauffman.[1] As usual the drawings were made with the aid of a camera lucida, using an oil immersion lens and treating the spores with an iodine stain. The magnification is about 1500 times. The spores examined were taken from type specimens.

The following species of *Lactaria* has been found in Florida for several seasons, occurring in abundance through November, and December 1940 and January 1941.

Lactaria maculatipes sp. nov. (FIG. 9, 14)

Pileus broadly convex with inrolled margin becoming centrally depressed, finally shallowly infundibuliform with uplifted margin, nearly white at first becoming tinted with honey yellow and closely zoned with deeper yellow, or with alternate rings of white sheen and pale ones of maize yellow (36 tone 2), usually made up of spots rather than of continuous bands, deepening in color with age, very viscid wet, up to 9 cm. broad; margin paler and plainly white-downy; context firm, latex-white, eventually pale yellow on the cut surface, bitter and slowly peppery without odor or slightly pleasant in odor; lamellae flesh color (167 tone 1) singly, deepening with age to chamois color or maize tone 4, unequal, a number forking near the stipe, narrow, close; stipe whitish with many maize yellow scrobiculate spots of various sizes, viscid when wet, becoming hollow, 2.5 cm. to 4 cm. $\times$ 1 cm. to 1.3 cm., equal or slightly narrower at the base; spores fleshy-white tone 1–2, broadly elliptical, echinulate reticulate, 7.5 μ $\times$ 8.75–9 μ.

[1] The Agaricaceae of Michigan. 1918.

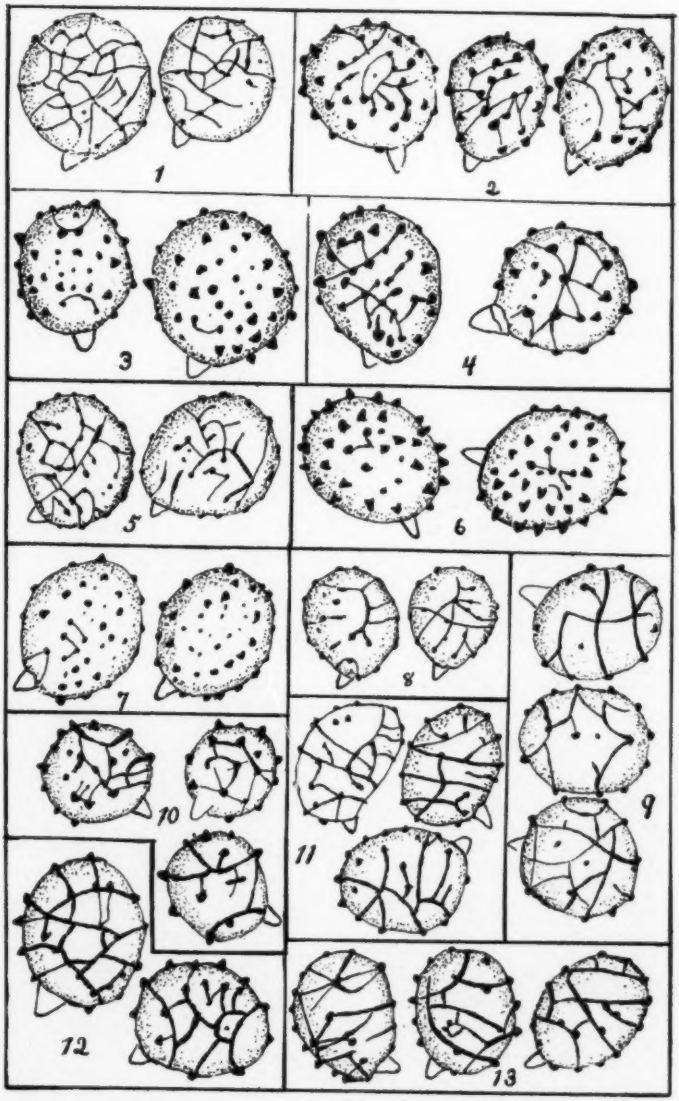


FIG. 1. *R. ochraleucoides;* 2, *R. subpunctata;* 3, *R. borealis;* 4, *R. tenuiceps;* 5, *R. aurantialutea;* 6, *R. sericeonitens;* 7, *R. amygdaloides;* 8, *R. sphagnophila;* 9, *Lactaria maculatipes;* 10, *L. delicata;* 11, *L. chrysorhea;* 12, *L. theiogala;* 13, *L. crocea.*

Pileo late convexo-depresso, postea subinfundibuliformo, zonato, primo albidulo, deinde malleo, zonis maculisve obscurioribus picto, viscoso, margine involuto primitis et albo-puberulo; carne firma subalba, fracta tardissime pallide ochroleuca e lacte, inodora aut odore debili et grato; lacte copioso albo, vix mutante sed sicco pallide ochroleuco, amaro et tarde acri; lamellis carnecoloribus (167 t-1) deinde obscurioribus, inaequalibus, saepe ad stipitem furcatis, angustis, confertis; stipite subalbido, subochroleuco scrobiculato, viscido udo, solido deinde cavo, 2.5 cm.–4 cm. × 1.2 cm.–1.3 cm., aequalo aut basi leviter constricto; sporis carnealbis echinulatis, reticulatis, late ellipticis, 7.5 μ × 8.75–9 μ.

TYPE LOCALITY: A hammock two miles east of Fort Christmas, Florida.

HABITAT: Under live oaks in moist humus, often gregarious, November through January if rains occur.

DISTRIBUTION: In various places in the same hammock and on Route 24 about three miles North of Apopka, Florida.

This species can readily be distinguished by its pallid closely zoned pileus and scrobiculate stipe and the unchanging latex except as it may in from ten minutes to an hour stain the flesh pale yellow. Rarely does the latex show any change in a drop. From the related species, *L. chrysorhea, L. theiogala* and *L. crocea* it differs in this respect as the change to yellow occurs quickly in them. From *L. scrobiculata* it also differs in the lack of tomentum on the margin. In North American Flora I described the stipe of *L. chrysorhea* as sometimes spotted. In my own collections of this species I have never found it so and believe either *Lacteria crocea* or this species may have been confused with it. The species described by W. C. Coker in the Lactarias of North Carolina is evidently not *L. chrysorhea* but possibly *L. delicata* as both of these have a strong odor while *L. chrysorhea* lacks any special odor. His figure on Plate 25 is evidently not *L. chrysorhea.* Spores of *L. chrysorhea* are not pure white as sometimes described but in a mass print are pale blush 137 tone 1, when the spore print is fresh, while those of *Lactaria maculatipes* (FIG. 9) are fleshy-white, larger and more broadly elliptical than in the former species. The spores of *L. delicata* (FIG. 10) are smaller than either of the others, the protuberances larger, and connected by bands as well as some lines, while even under the 1/6 power some spines are plainly larger than others. The spores of *L. theiogala* (FIG. 12) are larger than those

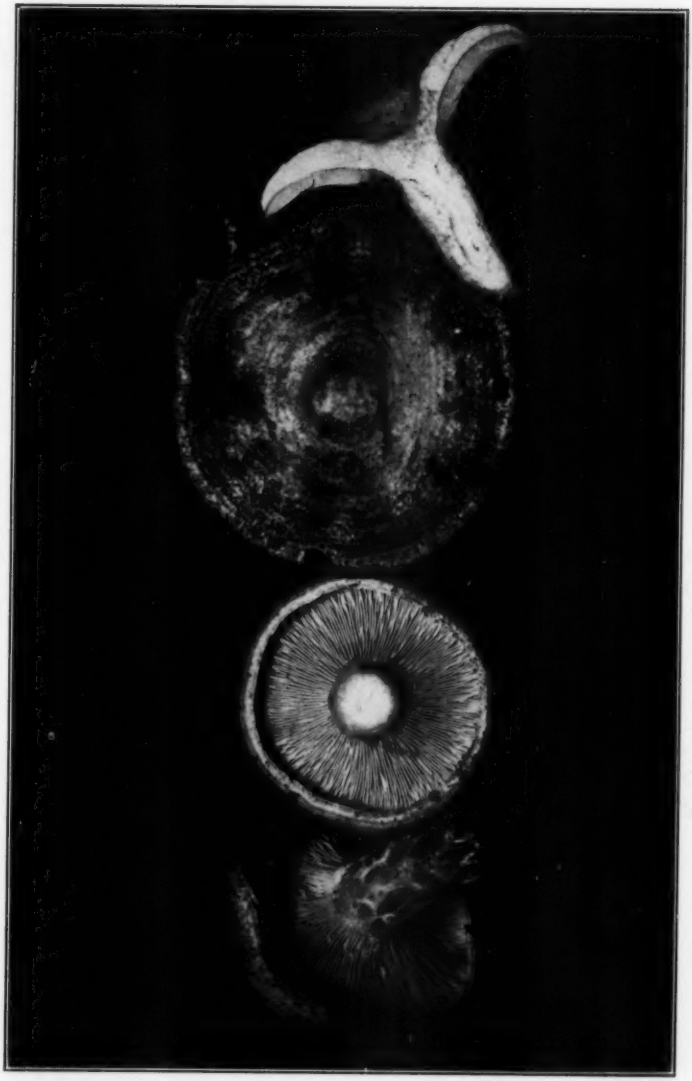


FIG. 14. *Lactaria maculatipes*. Natural size, sometimes larger.

of *L. chrysorhea* (FIG. 11), more broadly elliptical, and have larger protuberances. Hence the spores may be the means of distinguishing between these two species. The spores of *L. crocea* (FIG. 13) are banded with scattered protuberances on the bands, and there are some connecting lines. The spores are slightly larger and more elongated than those of *L. delicata*. They vary in size from 6.87 μ $\times$ 8–9 μ.

Type specimens of *Lactaria maculatipes* are deposited in the herbarium of the New York Botanical Garden and in my own herbarium.

EXPLANATIONS OF FIGURES

FIG. 1, *Russula ochraleucoides* Kauff. Spores globose to subglobose, 7–9 μ including the apiculus, with small protuberances connected by lines.

FIG. 2, *R. subpunctata* Kauff. Spores 6.87–7.5 μ $\times$ 8–8.75 μ exclusive of apiculus (7–9 μ $\times$ 9–11 μ including apiculus Kauff.), having fairly large protuberances varying in size with lines connecting some.

FIG. 3, *R. borealis* Kauff. Spores subglobose with protuberances varying in size and some granules with a few very fine connecting lines.

FIG. 4, *R. tenuiceps* Kauff. Spores rather coarsely echinulate, protuberances varying in size, many connected by bands or fine lines, 6.25 μ $\times$ 7.5 to 6.87 μ $\times$ 7.5 μ (6–8 μ Kauff.).

FIG. 5, *R. aurantialutea* Kauff. Spores with small protuberances of various sizes connected by thin bands or lines, subglobose, 7.5 μ $\times$ 8–8.75 μ.

FIG. 6, *R. sericeonitens* Kauff. Spores broadly elliptical, very echinulate, the protuberances varying in size, and a few connected by lines. 7.5–8 μ $\times$ 8.75–10 μ.

FIG. 7, *R. amygdaloides* Kauff. Spores broadly elliptical having protuberances of different sizes, scarcely any lines appearing. 7.5–8 μ $\times$ 8.75–9 μ.

FIG. 8, *R. sphagnophila* Kauff. Spores tuberculate with fine lines connecting some protuberances. 6.25 μ $\times$ 7.5 μ, subglobose.

STUDIES IN THE GASTEROMYCETES IV. A NEW SPECIES OF GEASTER

W. H. Long

(WITH 6 FIGURES)

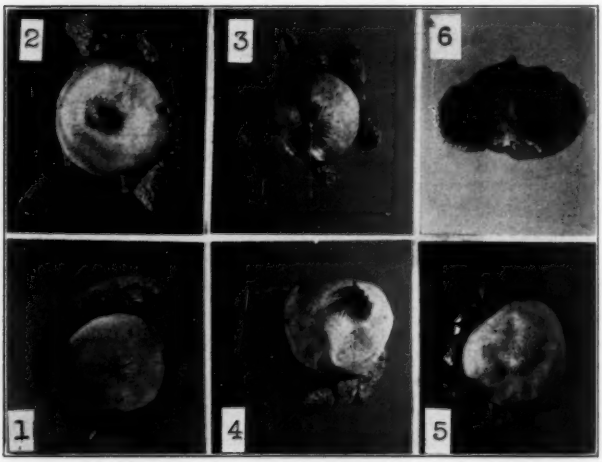
The writer while studying his many collections of Geasters, mainly of material from the southwestern United States, found a sulcate-mouthed plant which apparently does not belong to any known species. A new species is therefore proposed for this *Geaster*.

Geaster xerophilus sp. nov.

Sporophore hypogeous, small, the button subglobose to strongly depressed-globose or rarely concave on top, 1–2 cm. across, having a strong basal mycelial cord, becoming superficial and expanded at maturity then 1–4 cm. in diameter, usual size about 2 cm. *Exoperidium* saccate (FIG. 1) to explanate (FIG. 2, 3), split to about the middle or rarely to the center in old weathered plants; *rays* 7–12, pliable, not hygroscopic, unequal, blunt (FIG. 2, 3), tardily expanded or with the tips involute (FIG. 4, 5) around the endoperidium; *fleshy layer* cream buff to cinnamon color,[1] adnate, continuous, rarely rimose; *exterior* covered with sand held by the persistent, thin, strongly adnate mycelial layer which even in very old weathered plants is still retained; base concave with a prominent umbilical scar. *Endoperidium* subsessile to usually short-pedicellate, subglobose to strongly depressed-globose, often flattened on top (watch-shaped), 1–2 cm. across, light buff to drab gray when fresh, becoming pallid mouse gray to pale cartridge buff (whitish) with age, densely and minutely furfuraceous (but not asperate), lower ⅓ often enclosed by the saccate base of the exoperidium. *Peristome* small, circular or sometimes elliptic (FIG.

[1] All colors used in this article are after Ridgway, R. Color standards and color nomenclature. 1912.

2, 3), acute, sulcate with 18–30 sulci of unequal thickness and length, some not extending to apex of peristome, not seated in a depressed area, concolorous or rarely darker, in age often becoming expanded into a gaping mouth (FIG. 4). *Gleba* mummy brown when fresh becoming snuff brown with age; *columella* prominent (FIG. 6), cylindrical, expanding at top into a persistent globose mass of hyphae; *capillitium* simple, snuff brown under the microscope,



FIGS. 1–6. *Geaster xerophilus*, × 1¼.

4–4.5 microns thick. *Spores* globose, 1-guttulate, 4.2–5 microns in diameter, semi-opaque in water mountant; *epispore* chestnut brown, coarsely verrucose.

HABITAT: Solitary or in small groups of 2 or 3 plants, in open, sandy areas or rarely in partial shade of desert plants; in hot dry regions.

DISTRIBUTION: New Mexico, Dona Ana County, Jornado Experimental Range, elevation 4150 feet, *Ivan H. Crowell*, February 6, 1937—*2 plants* no. 8078: *Ivan H. Crowell, W. H. Long* and *Victor O. Sandberg*, May 2, 1937—*2 plants* no. 8182: *W. H. Long*, June 6, 1938—*3 plants* no. 9295; November 12, 1938—*8 plants* no. 8285 *Type and 4 plants* no. 8281; October 2, 1939—*7 plants*

nos. 8400, 8772 and 9378. Lincoln County, 25 miles northwest of Corona, elevation 7100 feet, *W. H. Long* and *David J. Stouffer*, April 20, 1940—*2 plants* no. 9289. Bernalillo County, near Albuquerque, elevation 5000 feet, *W. H. Long*, June 25, 26 and 27, 1941—*6 plants* nos. 9362, 9368 and 9370. Sandoval County, 5½ miles west of San Ysidro, elevation 6250 feet, *W. H. Long*, July 9, 1941—*19 plants* nos. 9379 and 9380; 2 miles south of the town of Bernalillo, elevation 5000 feet, July 12 and 17, 1941—*10 plants* nos. 9443 and 9453. A total of 63 plants collected to date (July 17, 1941). The above distribution of *Geaster xerophilus* shows a range extending from near Las Cruces in southern New Mexico northward 230 miles in the Rio Grande Valley to Albuquerque, thence southeastward 75 miles to near Corona, then northwestward 50 miles from Albuquerque on State Highway 44. The species probably occurs generally throughout the hot, semi-arid, sandy regions of New Mexico.

Geaster xerophilus is the only sulcate-mouthed *Geaster* which is saccate and has a pedicellate spore sac. *G. archeri* is also saccate and has a sulcate mouth, but its spore sac is sessile and not pedicellate.

The type locality of *G. xerophilus* is about 26 miles east of Las Cruces in the Jornado Experimental Range on areas known locally as the "Mesquite-Sandhill" formation, which consists of a succession of sandhills or dunes with tops covered by mesquite brush (*Prosopis glandulosa*), having bare areas and deep depressions between the dunes. The specimens collected were loose in the depressions or on level spots in the sand among the dunes, none were found on top of the sandhills under the mesquite bushes.

A nest of 15 young plants in various stages of development was found in the San Ysidro area buried in loose soil at the base of an old dead sage bush (*Artemisia*). In some the gleba was already brown while in others the color was still white. None of the buttons sectioned had developed any mouths although several were sufficiently mature to have the spore sacs separated from the exoperidium, in such an advanced stage one would expect peristomes to be showing.

The xerophytic habit of *Geaster xerophilus* is unique in this genus. It develops some 1 to 2 inches below the surface of the

sand, with little evidence of decaying vegetation or humus in the soil and usually without any shade. This growth habit is in marked contrast to that of the other species of *Geaster* found in the hot regions of the southwest where the writer has collected hundreds of plants of many different species all growing in the direct shade of trees or desert shrubs; however one species, *G. mammosus,* is often found in partial shade, apparently this species does not require much shade or leaf debris for its development.

All species of *Geaster* in my territory are hypogeous when young and remain so until expansion. I have never seen a truly epigeous *Geaster* in the dry southwestern regions. The reason for this is evident, in that our climate below 8000 feet elevation is too dry for species of *Geaster* to grow on top of the ground as some species do in the humid regions of the north and east. This need of moisture also explains their presence under trees and shrubs where the moisture is retained until these fungi mature.

ALBUQUERQUE, NEW MEXICO

A SPECIES OF PORIA CAUSING ROT AND CANKERS OF HICKORY AND OAK

W. A. Campbell and Ross W. Davidson

(with 3 figures)

INTRODUCTION

Recent investigations of decay in hardwoods have revealed many decay fungi which ordinarily do not produce sporophores on living infected trees (**4**, **6**). Several such fungi, for example, *Polyporus glomeratus* Peck (**2**) and *Fomes igniarius* var. *laevigatus* (Fries) Overh. (**3**), usually produce masses of hardened sterile mycelium, often accompanied by cankering, at various heights on the trunks of trees which they infect. These masses of sterile mycelium commonly fill open or partially healed branch stubs or other infection points and may form elsewhere on the trunk, depending upon the progress of the rot within the tree. In time infected trees die and break off at a rot-weakened spot and sporophores develop on the dead standing snags and down logs after a lapse of one to several years.

A rot disease of this type has been observed recently on pignut and shagbark hickories (*Hicoria glabra* (Miller) Sweet and *Hicoria ovata* (Miller) Britton) and on several species of oak.[1] A *Poria*, herein described as *Poria spiculosa*, was collected on down logs and dead, standing trees of hickory and oak (fig. 1, *A*). The relationship between this *Poria* and the fungus present in the rot and cankers of living trees was demonstrated by pure-culture methods.

Poria spiculosa sp. nov.

Sporophore perennial, effused in patches or in a continuous mass up to 1.5 m. in length on the bark or decorticated surface of thor-

[1] These observations were made in part during visits to farm woodlot improvement plots of the Soil Conservation Service in Region 1. The assistance of the following foresters of the Soil Conservation Service and the Civilian Conservation Corps in obtaining specimens is gratefully acknowledged: A. J. Agar, N. H. Caryll, S. M. Fullerton, V. C. Miles, and R. K. Ziebarth.

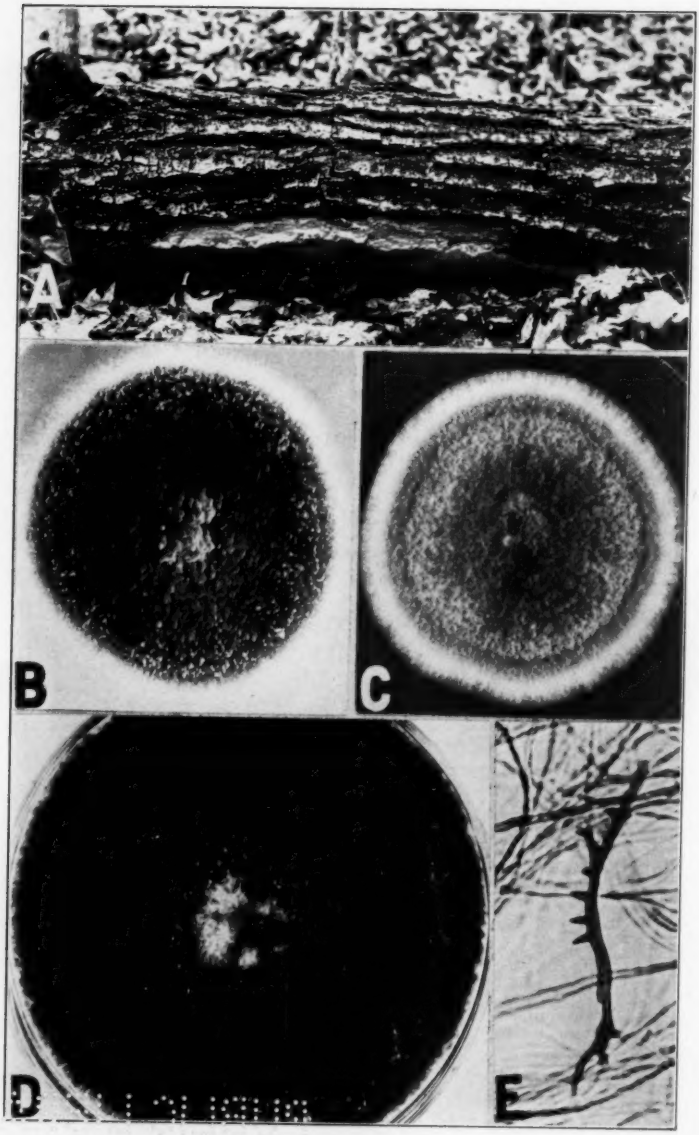


FIG. 1

oughly decayed logs and snags, occasionally on the dead tops of living trees; usually associated with trunk cankers or unhealed branch scars which are filled with masses of sterile fungus material; pore surface brown ("Snuff Brown," "Saccardo's Umber," and "Olive-Brown"[2]), whitish or grayish with age, smooth when young becoming checked and cracked with drying; context brown ("Snuff Brown"), firm but not hard; tube layers distinct, tubes 2–5 mm. long; subiculum thin, usually less than .5 mm. thick, pores 6 to 8 per mm.

Setae few or abundant, often lacking in cross-sections of the tubes but readily seen in longitudinal sections, unevenly distributed, bulbous at the base, not projecting strongly, 10–20 × 5–8 μ; spores hyaline, globose or subglobose, 3.5–4.5 μ in diameter; hyphae of subiculum smooth, uniformly 3–4 μ in diameter; yellow or brown; occasional hypha with sharp pointed, short side branches of the type referred to in the description of cultures as "setae-bearing hyphae." These are more abundant but often difficult to demonstrate in the mycelial plugs which fill the space in back of the sterile knots and cankers.

TYPE OF ROT: A white trunk rot of living trees usually associated with cankers or branch scars filled with sterile fungus material.

DISTRIBUTION: On living and dead hickory and oak. Sporophores have been collected in Pennsylvania, Delaware, Virginia, and North Carolina. Type specimen Forest Pathology no. *94090*, on shagbark hickory, Saltsburg, Westmoreland Co., Pennsylvania, collected January 1941. The type has been deposited in the Mycological Collections of the Bureau of Plant Industry, U. S. Department of Agriculture, Washington, D. C.

Sporophora perennis, brunnea, juvenilis glabra, vetusta rimosa; tubuli 2–5 mm. longi; subiculum tenue, plerumque minus quam 0.5 mm. crassum; pori 6–8 per mm.; setae paucae vel abundantes, 10–20 μ longae, 5–8 μ latae; sporae hyalinae, globosae vel subglobosae, 3.5–4.5 μ; hyphae imprimis 3–4 μ in diam., glabrae, flavae vel brunneae; hyphae setigerae in materia fungosa sterili cancris consociata et interdum in subiculo visae, etiam regulariter in culturis productae.

[2] All colors in quotation marks are from Ridgway (**5**).

[3] Latin description prepared by Miss Edith K. Cash.

FIG. 1. *A, B,* and *E. Poria spiculosa. A,* Sporophore on Underside of hickory log. *B,* 14-day-old culture. *C,* 14-day-old culture of *Poria prunicola. D,* 14-day-old culture of *Fomes igniarius* var. *laevigatus* (Fries) Overh. from birch. *E,* Setae-bearing hyphae from culture of *Poria spiculosa.*

In truncis dejectis erectisque *Hicoriae* et *Quercus* cancris et cicatricibus ramorum materia fungosa sterili impletis consociata.[3]

CULTURAL CHARACTERISTICS: Growth medium, forming in 14 days a mat 5 to 7 cm. in diameter;[4] mat appressed, very tough leathery or chamois-like, usually azonate but occasionally somewhat zoned, surface woolly or finely nodulose; mat with exception of a narrow white marginal zone 30 to 50 mm. wide evenly colored "Honey Yellow," "Isabella Color," to "Antimony Yellow" and "Buckthorn Brown;" boundary between colored center and white margin "Pale Orange-Yellow" to "Warm Buff" (FIG. 1, *B*).

Hyphae from white margin staining in eosin, 1–5 μ in diameter, sparingly branched, without clamps; non-staining fibrous hyphae colorless, yellow or brown, 1–5 μ in diameter; setae-bearing hyphae yellow or brown, few or many, usually difficult to demonstrate in older cultures because of the tough leathery mat in which they are embedded (FIG. 1, *E*).

DISTINGUISHING CHARACTERISTICS: *Poria spiculosa, Fomes igniarius* var. *laevigatus,* and *Poria prunicola* (Murr.) Sacc. & Trott. are closely related species which cannot be separated on morphological characters of the sporophores. They are however quite distinct in culture. *F. igniarius* var. *laevigatus* (FIG. 1, *D*) is faster growing than either *P. prunicola* (FIG. 1, *C*) (1) or *P. spiculosa* and lacks the setae-bearing hyphae of the latter. In addition, cultures of *F. igniarius* var. *laevigatus* kept in the dark often develop a "wintergreen" odor. *P. spiculosa* and *P. prunicola* grow at the same rate in culture but the former produces a very tough leathery mat in contrast to the softer, raised spongy mat of the latter. *P. spiculosa* can be separated from all other brown polypores studied to date by the setae-bearing hyphae which it produces in culture and which are found in the mycelial plugs formed in rotted wood.

These three fungi can be separated fairly consistently on host preference and type of rot. *P. prunicola* appears to be confined to species of *Prunus,* and in *Prunus serotina* produces a red mottled rot of the heartwood unaccompanied by cankers or sterile mycelium. *P. spiculosa* has been noted only on oak and hickory and is usually

[4] Description based on 28 isolates grown in 90 mm. Petri dishes on 2 percent Difco malt agar in diffused light at room temperature.

accompanied by cankering and sterile mycelium. *F. igniarius* var. *laevigatus* occurs on a greater variety of hosts but is most common on *Betula*. Determinations of this species on the basis of cultures have been made on oak and maple. Reports of *F. igniarius* var. *laevigatus* on *Prunus* and *P. prunicola* on hosts other than *Prunus* must be discounted unless the association is proven by cultures.

CANKERS AND ROT OF HICKORY

Poria spiculosa cankers of hickory vary considerably in appearance, depending upon the size and vigor of the infected tree and upon the age of the canker. The common form on hickory develops around a branch wound and resembles a nearly healed, swollen wound having a well-developed callus which appears to be bursting outward from internal pressure (FIG. 2, *A*). On large trees these may become prominent burl-like bodies having several vertical or irregular folds in the callus covering (FIG. 2, *C*). Sterile fungus material is always present in these cankers and often protrudes as an inconspicuous bark-like filling in the cracks between the callus folds (FIG. 2, *B* and *D*). An ax cut into the canker exposes a hard black or brown outer fungus crust and a cavity filled with spongy, lightweight, yellow or brown mycelium. Occasionally open cankers develop on the trunk. These usually have a depressed center filled with hardened mycelium and a prominent callus ridge. With age or from other causes this fungus material may disappear from the center leaving a cavity surrounded by raised callus tissue.

A slightly protruding core of fungus material which resembles the remains of a stub sometimes forms in the branch wound of an infected tree. Such evidences of infection are difficult to detect, especially if there is but little stimulation of callus growth around the wound. Manifestations of this type cannot properly be called cankers since there is little or no killing of the cambium. However, these appear to be early stages of infection, and further extension of the rot probably results in the typical canker phase commonly found on older infected trees.

The most characteristic feature of the disease is the yellow or brown mycelial plug which forms in back of the canker and which extends some distance into the rotted wood (FIG. 2, *B*). This my-

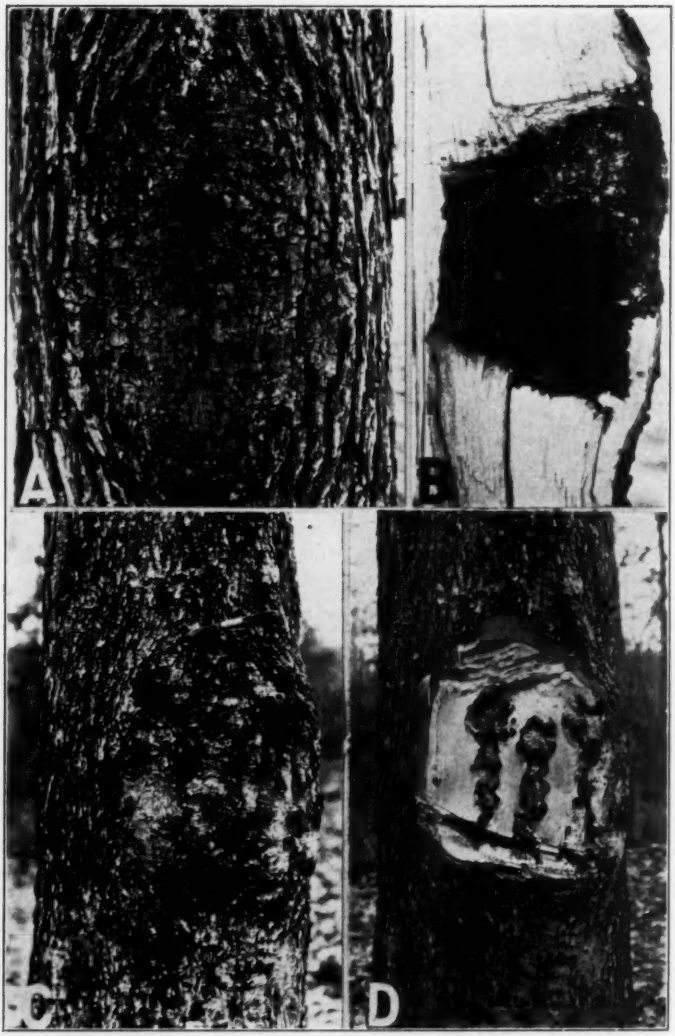


FIG. 2. *Poria spiculosa* in hickory. *A* and *C*, Burl-like cankers which are associated with heartrot. *B*, A longitudinal section through *A* showing heartrot in center of tree and dark brown mycelial mass extending from decay to outer surface. *D*, Burl in *C* with outer surface removed to expose mycelial plugs.

celial plug replaces the decayed wood near the surface and possibly enables the fungus to obtain air by preventing the healing of the infection court. It is formed of tough spongy mycelium composed of smooth yellow or brown hyphae. Irregular dark brown hyphae having short setae-like projections are also present but are not evenly distributed and are often difficult to demonstrate in microscopic mounts made from this material. These are also produced in pure culture by the fungus.

Observations have been made on 25 living infected pignut and 5 shagbark hickories varying in diameter from 4 to 18 inches at breast height. Most of the infected trees had a single canker usually on the lower trunk. One tree had two cankers at heights of 4 and 6 feet respectively, and one had several cankers, the lowest at 3 feet and the highest approximately 15 feet from the ground. Three trees were dissected in order to study the extent of decay and the condition of the cankers. Two had been infected through branch stubs and the third is assumed to have been, although the wounds were too badly decayed to be certain. In the case of trees not dissected, the position of diseased branch wounds point to these as the usual entrance courts for the fungus. Not all cankers indicate separate infections. Badly rotted trees may develop cankers at various heights which are caused by the extension of the decay through branch traces and stubs to the outside bark.

In the advanced stage the rot is soft, powdery, and dry. In earlier stages the rot is soft and white or slightly yellowish, and is sharply delimited from the sound wood. In the trees that were dissected the rot extended from ground line to an average of 12 feet. A single trunk canker probably indicates that the butt log is badly affected and multiple cankers are evidence that the entire trunk is decayed.

No comparative study of hickory decays has been undertaken, but from present observations *P. spiculosa* appears to be one of the most important causes of decay in hickories. Cankered and decayed pignut hickories have been found in North Carolina, Pennsylvania, Virginia, and West Virginia. Infected shagbark hickories have been found in Pennsylvania. This decay probably occurs in hickories in other areas.

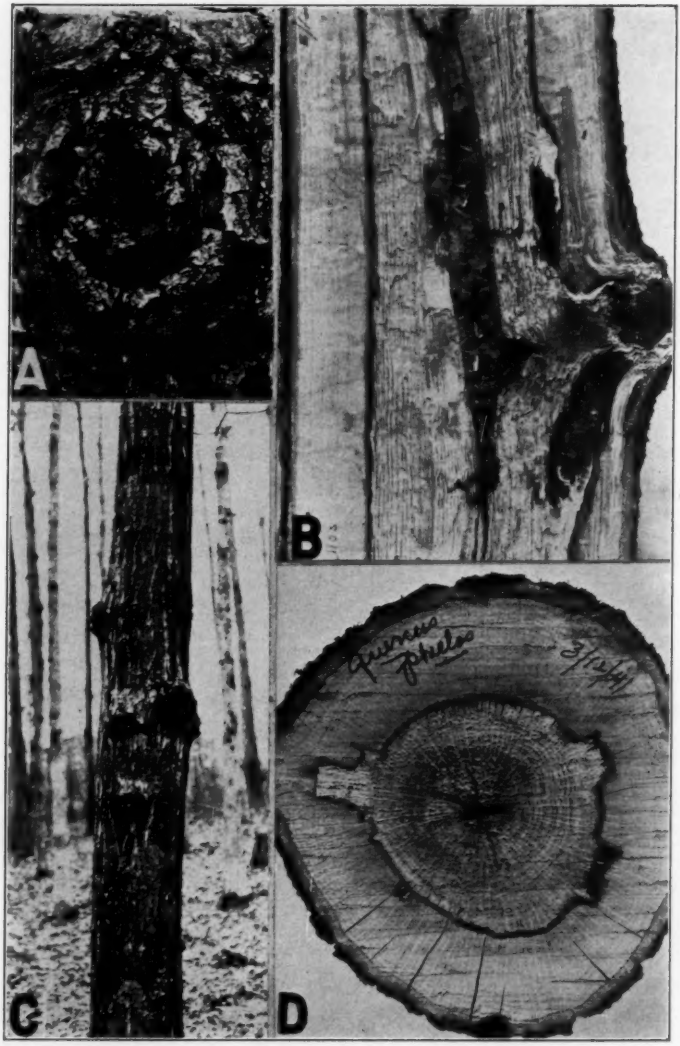


FIG. 3. *Poria spiculosa* in oaks. *A*, Infected branch trace. *B*, Longitudinal section through infected oak trunk showing decay and mycelial plug back of branch scar. *C*, Numerous swollen branch scars which are evidence of infection. *D*, Cross-section of infected trunk.

CANKERS AND ROT OF OAK

Definite canker formation of the type described as common on hickory was noted less frequently on oak. The usual evidence of *Poria spiculosa* decay consisted of an inconspicuous protrusion of sterile fungus material from a branch trace unaccompanied by pronounced swelling or callusing (FIG. 3, *A*). This sterile fungus material resembled an ordinary branch stub so closely that a definite diagnosis could be made only by cutting into the branch scar. The cut would reveal an outer hardened fungus crust which was the same color as the oak bark and a softer mycelial plug which filled the space formerly occupied by the branch stub. The cavity usually had only a narrow lining of decayed wood in the outer sapwood. A longitudinal cut through the infected stub revealed the mycelial plug filling the branch opening and its connection with the rotted heartwood (FIG. 3, *B*).

Open cankers with a depressed center and moderate or slight callusing were occasionally found, especially on willow oak (*Quercus phellos* L.). Burl-like cankers were also found on several oak species. These usually had a roughened surface with many irregular callus folds. The cracks in these folds were filled with sterile fungus material and dissection of the burls showed that these mycelial masses were connected with a central core of rot.

Rot is confined to the heartwood and is typically soft, white, and spongy (FIG. 3, *C*). Cavities form near branch-stub openings and these are filled with mycelial masses which extend to the outside through branch stubs and cankers. With the extension of rot in the heartwood, sterile masses of mycelium become evident at enlarged branch scars up and down the trunk (FIG. 3, *D*). All evidence indicates that branch stubs are the usual infection points.

Poria spiculosa was not encountered in previous oak decay studies (**4**) but from recent observations based on external evidence of decay it appears to be one of the more important species in Atlantic Coastal areas on such hosts as *Quercus nigra* L., *Q. phellos*, and *Q. rubra* L. It occurs less frequently in oaks in the mountain regions. It was found in the following species of oaks: Willow oak, Delaware, Virginia, and North Carolina; water oak (*Q. nigra*)

and blackjack oak (*Q. marilandica* Muench.), North Carolina; southern red oak (*Q. rubra*) and other *Quercus* spp., Virginia, and North Carolina.

CIVILIAN CONSERVATION CORPS AND
BUREAU OF PLANT INDUSTRY, U. S.
DEPARTMENT OF AGRICULTURE,
WASHINGTON, D. C.

LITERATURE CITED

1. **Baxter, Dow V.** Some resupinate polypores from the region of the Great Lakes. V. Papers Mich. Acad. Sci. **19** (1933): 305–332. *Illus.* 1934.
2. **Campbell, W. A. & Ross W. Davidson.** Sterile conks of *Polyporus glomeratus* and associated cankers on beech and red maple. Mycologia **31**: 606–611. *Illus.* 1939.
3. —— **&** ——. Cankers and decay of yellow birch associated with *Fomes igniarius* var. *laevigatus*. Jour. Forestry **39**: 559–560. *Illus.* 1941.
4. **Davidson, Ross W., W. A. Campbell & Dorothy Blaisdell Vaughn.** Fungi causing decay of living oaks in the eastern United States and their cultural identification. U. S. Dept. Agr. Tech. Bull. 785. [In press.]
5. **Ridgway, R.** Color standards and color nomenclature. 43 pp. *Illus.* Washington, D. C. 1912.
6. **Roth, Elmer R. & Bailey Sleeth.** Butt rot in unburned sprout oak stands. U. S. Dept. Agr. Tech. Bull. 684. 43 pp. *Illus.* 1939.

VENTURIA ACERINA, THE PERFECT STAGE OF CLADOSPORIUM HUMILE [1]

A. G. PLAKIDAS

(WITH 3 FIGURES)

On August 30, 1940, while out collecting in the vicinity of Ithaca (near Buttermilk Falls), Professor H. H. Whetzel called attention to prominent spots on leaves of red maple (*Acer rubrum*) which appeared to be distinctly different from any of the common leaf spots of maple. He thought that this might be a new or undescribed disease. A cursory examination of the specimens, disclosing the fasciculate conidiophores and the oblong conidia, suggested that the fungus might be a *Cercospora*. He therefore turned the specimens over to Dr. Chupp, who, in turn, asked the writer to make a critical examination of the material in an attempt to determine the identity of the fungus.

The writer made additional collections of the same leaf spot on red maple on October 2, 1940, near Enfield Glen, N. Y., and again a week later at Watkins Glen, N. Y., on the same suscept. Then on February 28, 1941, in examining various specimens collected near Millinocket, Maine, on August 22, 1940, the same fungus was found on spots on red maple leaves. The spots on the Maine material were, for the most part, small and not typical. Still later, on May 12, 1941, the same spots were found on fallen maple leaves in the Lloyd Preserve, McLean, N. Y. So it is evident that this disease, although not very common, is not particularly rare.

[1] This investigation was conducted at Cornell University while the author was spending his sabbatic year (1940–1941) there under a grant from the General Education Board. The author wishes to express his grateful appreciation to Dr. L. M. Massey, Head of the Department of Plant Pathology, Cornell University, for his kindness in making the facilities of the Department available to him, to Professors H. H. Whetzel, H. M. Fitzpatrick, and Charles Chupp for helpful advice and many courtesies, and to Dr. C. L. Shear for kindly examining specimens and confirming his determination of the generic position of the fungus.

Pieces of leaf tissue from the younger spots were planted on agar, and a gray fungus, which produced conidia in culture (FIG. 2, *B*) identical with those on the leaves, was easily and repeatedly isolated. The fungus grows well in culture on a variety of media, forming medium-sized colonies gray on top and black in reverse. In addition to this fungus, a species of *Ramularia* (probably *R. lethalis*), and *Sphaeropsis* sp. were occasionally isolated from tissue plantings.

DESCRIPTION OF THE DISEASE

The spots (FIG. 1) are numerous, varying in size from very small (0.5–1 mm.) to very large (10–20 mm.). The youngest spots appear as black dots, 0.5–1 mm., round to angular, with a pale-green halo. The older spots are angular to suborbicular, with irregular margins surrounded by a pale-green halo. The upper surface is dark reddish-brown, the lower surface lead-gray. Older spots are zonate, the degree of zonation varying with the size of the spot. The smaller of the older spots are marked by only one narrow ring or zone of light-brown tissue surrounding the darker center. The larger spots may have 2–4 such zones or rings. Coalescence of the spots occurs, forming very large irregular necrotic areas in the leaf. Both surfaces of the spots are covered with a network of light-brown septate mycelium from which arise short, brown, conidiophores bearing oblong to fusoid-cylindric, catenulate, unicellular to 1-septate, olive-brown conidia (FIG. 2, *A*). Most of the conidiophores arise singly as lateral branches of the surface mycelium, but some arise in fascicles from a more or less tuberculate stroma (FIG. 2, *C*).

IDENTITY OF THE DISEASE

It appeared probable from examination of the literature that the disease under investigation is the same as the maple leaf spot described by J. J. Davis[2] as caused by *Cladosporium humile*. A sample of the Davis collection was obtained from the herbarium of the University of Wisconsin, through the kindness of Dr. H. C. Greene, for comparison with the Cornell material. This specimen

[2] Trans. Wisc. Acad. **19**: 702. 1919.

(a leaf of *Acer saccharinum*) was not part of Davis' type material, but represented a second collection made by him at Arcadia, Wisconsin, September 7, 1917. The type collection, which was not examined by the writer, was made from *Acer rubrum*, Luck, Wisconsin, August 25, 1916.

FIG. 1. Leaf of *Acer rubrum* L. showing typical spots, × 1.5.

The Wisconsin material proved to be co-specific with that of ours as evidenced by macroscopic symptoms and morphology of the fungus. It was considered desirable to determine how the fungus overwintered, for it was believed likely that its perfect stage would be found if search were made for it. Accordingly, samples of spotted leaves collected in November were placed outdoors in a wire basket and examined periodically during the spring of 1941.

DISCOVERY OF THE ASCIGEROUS STAGE

The first sample of the overwintered leaves was examined on April 15. Neither conidia nor ascospores were found. The leaves were very dry. Then on April 22, following a week of unseasonable warm weather (the temperature rose to 88.5° F. on April 20) during which intermittent rains fell, a second sample of leaves was examined. Conidia, borne both on fasciculate and on single conidiophores, were found to be fairly abundant. It was not known for certain whether these conidia were old, that is, remnants from the previous late summer and fall, or whether they

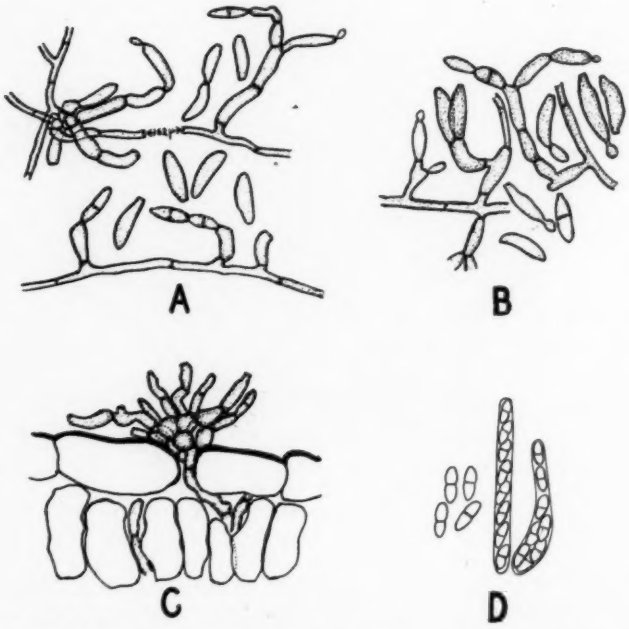


FIG. 2. Conidiophores, conidia, asci and ascospores of *Venturia acerina*. *A*, camera lucida drawing of mycelium, conidiophores and conidia from the under surface of a leaf spot, × 400; *B*, camera lucida drawing of mycelium, conidiophores and conidia from a 7-day-old culture on beanpod agar, × 400; *C*, camera lucida drawing of a paraffin, stained section of leaf showing fascicle of conidiophores on the upper surface and fragments of mycelium in the tissue, × 400; *D*, asci and ascospores, × 375.

had just formed from mycelium overwintered in the leaf tissue. The latter seemed to be true, however, for the conidia appeared fresh and germinated readily when sown on agar. Furthermore, no conidia had been found on the first sample of leaves taken a week earlier during dry weather. It appeared certain that the conidia had developed during the warm, moist weather that prevailed during the preceding week. To test this point further, the leaves were washed in running water with a stiff brush to remove the conidia from their surfaces and placed in a moist chamber. When examined four days later, a new crop of conidia had formed. This procedure was repeated a week later and like results were obtained. Thus it was established that the fungus is able to survive the winter in the mycelial stage in, or on, the leaf and to produce conidia in the spring. This is not the only method of overwintering, for, as will be seen, the fungus also produces ascospores.

On May 8, overwintered leaves which had been washed and placed in a moist chamber a week earlier were examined. Spiny perithecia (FIG. 3), evidently those of a *Venturia*, were found singly or in groups mostly on the under surface of the leaves and around the areas covered by the original spots. The perithecia contained 2-celled, greenish-yellow to light-brown ascospores. Small pieces of the leaf areas bearing the perithecia were cut, stuck on moist filter paper in petri dish covers, and suspended over agar. Ascospores were discharged. Twelve single-ascospore cultures were obtained, and within a week to ten days all produced colonies and conidia identical with those of isolates made from tissue plantings or from sowings of conidia.

Since the overwintered leaves contained, in addition to the spiny perithecia, fructifications of several other fungi (*Mycosphaerella, Gnomonia, Physalospora, Pezizella*, etc.), the procedure described above for obtaining single ascospores was not considered entirely reliable because one could not tell with certainty from which fruit body the ascospores were discharged. Therefore, in another experiment, this method was used: single perithecia were picked out with the point of a needle and crushed in a drop of water on a cover slip. Then, by means of a micromanipulator, single asci, single ascospores, or groups of two or more ascospores,

were transferred to hanging agar drops on cover glasses over hollow slides.[3] After germination, these were transferred to agar slants in tubes.

Cultures were obtained from 4 single asci, 6 single ascospores, and 3 others originating from 2, 6, and 18 ascospores respectively. With a single exception, all cultures produced conidia identical with those of earlier isolations. The one exception was the isolation containing 18 ascospores. In this case, the colony was not transferred but was left on the slide in the hanging drop, and when the drop of agar began to dry, several perithecia, but no conidia, were produced. This was the only instance in which the fungus produced perithecia in culture.

Additional lots of overwintered leaves were examined on May 21 and 30. Conidia, but no perithecia, were found on the leaves as they were brought in from outdoors on both occasions. Perithecia, however, did develop on both lots of leaves after they had remained in a moist chamber 5–7 days. It is believed that the reason perithecia did not develop on the overwintered leaves outdoors was due to the near-drought conditions prevailing in the vicinity of Ithaca in the spring of 1941. The leaves outdoors were dry most of the time during April and May, and, judging by the behavior of the fungus in the moist chamber, prolonged high humidity is apparently essential for its perithecial development.

DESCRIPTION OF THE FUNGUS

The most conspicuous character of the fungus is the many prominent, dark-brown bristles covering the upper portion of the perithecium (FIG. 3). For the most part, the bristles are limited to the apex of the perithecium, but often they cover more than half of its exposed surface so that, when viewed from the top with a lens, the perithecia resemble microscopic sea urchins. From the region just below the spines, hyaline to light brown, flexuous, septate hairs of indeterminate length radiate in all directions. Some perithecia are nearly smooth, others have relatively few, short, bristles around the ostiolum, but typically they are decidedly

[3] The writer is indebted to Dr. E. M. Hildebrand who worked the micromanipulator in making these isolations.

spiny and hairy. In shape the perithecia vary from nearly globose to beaked. There is also considerable variation in the position of the perithecium in relation to the suscept tissues. Typically, approximately the basal one-half of the perithecium is sunken in the leaf tissue, but it is not uncommon to find perithecia entirely superficial, or completely sunken except for the emergent beaked ostiolar portion. The perithecia are chiefly hypophyllous, but

FIG. 3. Photomicrograph of section of perithecium, × 415.

occasionally some occur on the upper surface. The asci (FIG. 2, *D*) are sessile, obclavate at first with the spores imperfectly biseriate, elongating and becoming cylindrical, with the spores obliquely monostichous just before discharge. The ascospores are shot out with force from an apical pore. The pore did not turn blue with iodine. The ascospores are hyaline to greenish-yellow, 2-celled, the lower cell usually slightly smaller than the upper, and more or less constricted at the septum. There are no paraphyses, but paraphysoids occur.

The conidial form of the fungus causes definite spots in other-

wise healthy leaves. The conidiophores are amphigenous.[4] They are of two kinds as regards origin. The majority arise singly as lateral branches from a network of superficial mycelium, but they also occur in fascicles on a more or less tuberculate superficial stroma. Most of the fasciculate conidiophores are epiphyllous. Both are brown in color, usually septate, short and rigid to longish and flexuous, straight or geniculate, simple or branched, and bear oblong to fusoid-cylindrical, fuliginous, catenulate, straight to 1-septate conidia (FIG. 2, *A–C*).

The ascigerous form is obviously a *Venturia*. Dr. C. L. Shear kindly examined specimens submitted to him and confirmed this determination. No mention of *Venturia* on *Acer* has been found in the literature. It is possible, of course, that this fungus has been previously described on another suscept, but in view of our present limited knowledge of the pathogenetic specificity of many fungi, it is considered advisable to describe it as a new species, for which the following name is proposed.

TECHNICAL DESCRIPTION

Venturia acerina sp. nov.

Syn. *Cladosporium humile* J. J. Davis, Trans. Wisc. Acad. **19**: 702. 1919.

Perithecia scattered or gregarious, chiefly erumpent, occasionally superficial, membranous, dark colored, globose to beaked, typically beset with stiff dark brown non-septate bristles in the region of the apex and with hyaline to light brown septate hairs below (some are nearly smooth), ostiolate, 72–165 × 82–191 μ, average 106.3 × 132.0 μ; spines varying in length from 23.0 to 73.0 μ and in thickness from 4.5 to 6.6 μ, average 41.2 × 5.7 μ; asci sessile, obclavate at first with the spores imperfectly biseriate, becoming longer and cylindrical at maturity with the spores obliquely monostichous, 8-spored, 62.7–72.6 × 8.3–10.0 μ, average 66.7 × 9.7 μ; paraphyses absent; paraphysoids present; ascospores greenish-yellow, 2-celled, the lower cell slightly narrower, with or without constrictions at the septa, oblong elliptic, 12.5–14.8 × 4.3–5.0 μ, average 13.8 × 4.8 μ. Hab. in fallen leaves of *Acer rubrum* L.

[4] Davis (see footnote 2) states that the conidiophores are epiphyllous. He was obviously mistaken, for conidiophores and conidia were present in profusion on both surfaces of the Wisconsin specimen examined.

TYPE LOCALITY: Ithaca, N. Y., U. S. A.

TYPE SPECIMENS: Type specimens have been deposited in the herbarium of the Department of Plant Pathology, Cornell University (Accession No. *29477*), and in the herbarium of the Botany Department, Louisiana State University.

CONIDIAL STAGE: The conidial stage was described as *Cladosporium humile* by J. J. Davis from material on living leaves of *Acer rubrum* L. collected at Luck, Wisconsin, August 25, 1916. Davis also had before him two later collections on *Acer saccharinum* L. from Plover and Arcadia, Wisconsin. Since Davis' description is rather brief, a more detailed description is given here.

Conidiophores amphigenous, arising from a network of superficial hyaline to light brown, coarse, septate, mycelium either singly as lateral branches of the spreading hyphae, or in fascicles from a more or less tuberculate, black, superficial stroma, short and rigid to longish and flexuous, straight or geniculate, septate, simple or branched, fuliginous, 16.0–66.0 × 4.6–6.6 μ, average 31.7 × 5.9 μ; conidia acrogenous, oblong to fusoid-cylindrical, fuliginous, catenulate, unicellular or 1-septate, 15–27 × 4.6–6.3 μ, average 19.8 × 5.3 μ. On large necrotic spots in living leaves of *Acer rubrum* L. and *A. saccharinum* L.

Since most of the known conidial forms of *Venturia* spp. belong in the genus *Fusicladium*, it would perhaps have been advisable, for the sake of uniformity, to transfer the conidial stage of this fungus to that genus. The line of separation between *Cladosporium* and *Fusicladium* certainly is not very sharp, and, except for its catenulate conidia, this fungus would fit as well in the latter as in the former genus. But since the presence or absence of catenation in the conidia appears to be the chief taxonomic difference between the two genera, it was considered wise to leave the conidial stage of this fungus where it had been placed by Davis.

PATHOGENICITY

There can hardly be any doubt that the fungus is pathogenic, for it is always found associated with well-defined lesions from which it can be easily obtained in pure culture. Yet considerable difficulty was encountered in getting infection by artificial inoculation. Early in November, several red maple seedlings were potted

and placed in cold storage to break dormancy, then removed to the greenhouse early in January. By the middle of February, these had plenty of leaves to inoculate. In all, 21 separate inoculations were made between February 20 and May 28, some in the greenhouse and some outdoors, using conidial suspensions from several different isolates. With one exception, the results of the inoculation were either entirely negative, or light infection only resulted. The few spots that developed remained small and atypical. The one exception was in connection with one small potted tree inoculated in the greenhouse on March 23. Hundreds of spots developed on the inoculated leaves of this tree in about 10 days. The tree was removed to the outdoors on May 3, and the lesions continued to enlarge gradually until by July 18, when the last record was taken, the older spots were fairly typical. Conidiophores and conidia were present on these spots, and the fungus was readily reisolated by planting of the spotted leaf tissue.

It is suspected that the age of the leaf may condition its susceptibility. It is probable that senescent leaves are more susceptible than young ones. It is perhaps not accidental that all collections of this disease (Davis', Whetzel's, and the writer's) were made in late summer or early fall. Since the writer had to return to Louisiana, it was not possible to make inoculations in late summer.

SUMMARY

A leaf spot disease of the red maple (*Acer rubrum* L.) was collected near Ithaca, N. Y., August 30, 1940, and also near Millinocket, Maine, on August 22, 1940. This disease proved to be identical with that described by J. J. Davis in Wisconsin in 1919 and attributed to *Cladosporium humile*.

A fungus was isolated from the spotted leaves by planting pieces of the spotted tissue and also by culturing single conidia. All isolates thus obtained produced conidia in culture which were identical with those found on the leaf spots.

Infected leaves were collected in November and left outdoors to overwinter. In the spring, when some of the overwintered leaves were placed in moist chambers, perithecia of *Venturia* sp. developed on, and around, the areas occupied by the spots. Single-ascospore

isolations from these perithecia gave cultures identical in every respect with the cultures of *Cladosporium humile* obtained from spotted leaf tissue or from single conidia. Thus, cultural proof has been obtained that the ascigerous stage of *C. humile* is a *Venturia*. This is described as a new species under the name of *V. acerina*.

The fungus produced also conidia on the overwintered leaves in the spring. Thus it appears that the perfect stage is not essential for its overwintering.

DEPARTMENT OF PLANT PATHOLOGY,
CORNELL UNIVERSITY,
ITHACA, NEW YORK,
AND
DEPARTMENT OF BOTANY,
LOUISIANA AGRICULTURAL EXPERIMENT STATION,
BATON ROUGE, LOUISIANA

VARIATIONS OF SPECIFIC AND VARIETAL CHARACTER INDUCED IN AN ISOLATE OF BREVILEGNIA [1]

S. B. SALVIN [2]

(WITH 4 FIGURES)

The genus *Brevilegnia* was established by Coker (1) on the basis of the following characters: (1) the presence of a depauperate dense mycelium; (2) the development of zoösporangia which behaved "about as in *Thraustotheca*" (1, p. 212), *i.e.*, discharged the spores by an irregular rupture of the sporangium wall, which disappeared after maturity; (3) the variability in sporangiospore size and the frequent failure of these spores to emit secondary swarmers; and (4) the formation of small, monosporic oögonia. The type species was *B. unisperma* Coker, the distinguishing characters of which were the presence of many large, long-cylindrical sporangia; the complete disappearance of the sporangial wall simultaneous with the escape of the spores; the development of small, spherical, irregular, one-spored oögonia; the formation of androgynous, profusely branched and irregular antheridia; and the occurrence of zoöspores. Other species and varieties were later described by Coker and others, separated from the type on the basis of such properties as the size and shape of the sporangia, the presence or absence of antheridia, the motility or lack of motility of the zoöspores, and the formation or absence of gemmae.

When an isolate of *Brevilegnia* was obtained by the writer, attempts were made to determine to what species the fungus belonged. However, this was found impossible because of the wide variations in the morphology of the mycelium, asexual structures,

[1] Contribution from the Laboratories of Cryptogamic Botany and the Farlow Herbarium, Harvard University, no. 192.

[2] The writer expresses his gratitude to Prof. W. H. Weston, under whose guidance this investigation was conducted, for his valuable suggestions and continued interest.

and sexual bodies, and hence in the general appearance. If a single species of *Brevilegnia* could be so influenced by the environment as to fluctuate in its distinguishing characteristics, the validity of the method of species determination within the genus was obviously worthy of further investigation. In this paper, experiments and observations are presented which demonstrate that from a single isolate the characters of eight different species or varieties of the genus could be obtained by the adjustment of the external environmental conditions, such as temperature, oxygen tension, etc.

EXPERIMENTS AND RESULTS

The species of *Brevilegnia* discussed in this paper and referred to as *Brevilegnia* C–2 was collected and isolated from some dried mud, originally lying along a path in Soledad (Cienfuegos), Cuba.[3] From the mycelium resulting from the germination of a single zoospore, a pure culture was obtained, from which sterile hemp seed were inoculated and cultured in glass-redistilled water. The mycelium usually formed a coarse, dense growth, depauperate to extensive, with sporangia borne at the hyphal extremities and renewed by cymose branching. The method by which the sporangia matured and the spores were expelled is the same as that characteristic of the genus, as described in detail by Couch for *B. subclavata* (**5**).

INFLUENCE OF ENVIRONMENTAL VARIATIONS ON THE SPORANGIA.

Although the method of sporangial maturation was the same in the several types of environment, the eventual shape and size of the sporangia varied, depending on the condition of the surrounding medium. The mycelium was grown and formed sporangia in temperatures from 10° to 35° C., in quantities of water from 1 cc. to 2000 cc., in surroundings of both high and low oxygen content, and in various combinations of two or more of these conditions. Only one infected hemp seed was used for each environmental type, although each experiment was repeated several times.

In 50 cc. of well-aerated, glass-redistilled water at 25° C. in a

[3] The writer expresses his thanks to the Atkins Foundation for the grant enabling him to study and collect aquatic fungi at Soledad, and to Mr. Sturrock and Mr. Walsingham for their invaluable aid and coöperation.

four-inch Petri dish, 60.8 per cent of the sporangia (on the basis of 400 measurements) were long, cylindrical, and two spores in width (FIG. 1, *D*); 21 per cent were two spores in diameter at the

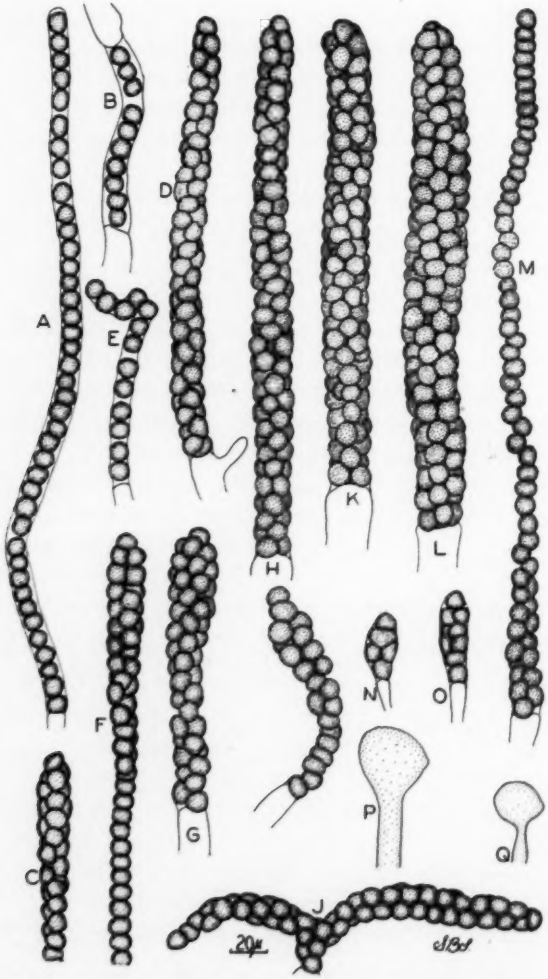


FIG. 1. Camera lucida drawing of different types of sporangia of *Brevilegnia* C-2. (Cf. text for details.)

tip and one at the base (FIG. 1, *F*); and 18.2 per cent averaged three or more spores in breadth (FIG. 1, *K–L*). However, it was found that generally, with temperature and degree of aerobiosis the same, the less water present, the wider the sporangia, and the more water, the thinner the sporangia (FIG. 2). For example, the sporangia developing in 1 cc. of water averaged 27.2 μ wide (FIG.

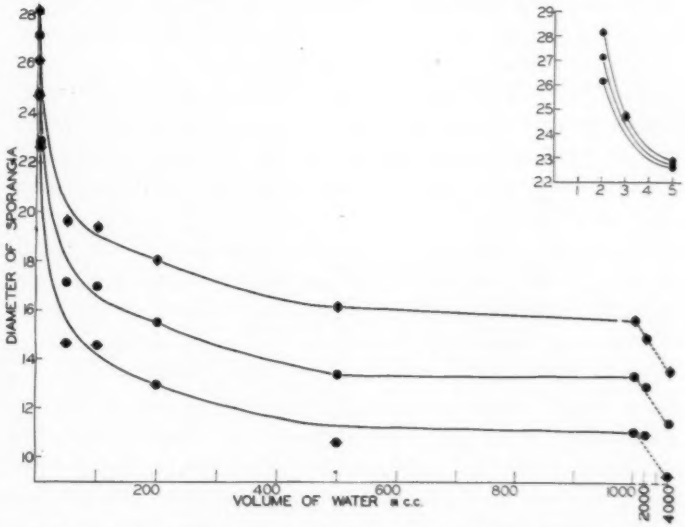


FIG. 2. Graph, showing the relation between the volume of water in which the fungus had been growing and the diameter of the sporangium of *Brevilegnia* C–2.

denotes the diameter of the sporangial base.
denotes the diameter of the sporangial apex.
denotes the diameter of the average of the base and apex.

1, *L*); those in 5 cc., 22.8 μ (FIG. 1, *K*); and so on, until those in 4000 cc. were 11.5 μ wide (FIG. 1, *A*, *B*, *E*).

To be sure, even under a constant environment, there were some sporangia that were not of the same type as the majority. For example, in 1500 cc. of well-aerated water at 25° C., 69.5 per cent of the sporangia were of the same thickness as the hyphae bearing them and had the spores arranged in a single row; 29.5 per cent had a double row of spores at the distal end and a single row at the

proximal; and 1 per cent were two or more spores in width throughout the entire length of the sporangia.

In addition, the temperature of the surrounding water definitely influenced the shape and size of the sporangia. At 35° C., many of the sporangia were not straight, but somewhat contorted or bent upon themselves (FIG. 1, *I*). The degree of this turning varied from just a slight bending away from the direction in which the hypha was growing to a U-shaped curve which brought the apex of the sporangium to a position near its base.

Also, at 35° C. in 25 cc. of water, an unusual shape of sporangium appeared in moderately large numbers—one which had a double row of spores at its proximal end, then divided into two forks each about two spores in width and bent at almost a 180° angle away from each other (FIG. 1, *J*).

In general, higher temperatures, *i.e.*, those above 25° C., tended to decrease the diameter of the sporangia, whereas those from 10°–25° C. seemed to have no constant and controlling effect.[4]

Since the above experiments on sporangial variations were started in absolutely pure water, with staling products naturally being formed later, it seemed desirable to study also the type of sporangium formed in a medium containing concentrated staling products. When the fungus was grown in water in which another colony had been developing for 10–14 days and which then had been drawn through a porcelain (Chamberland) filter, the sporangia that ultimately matured were almost exclusively short and clavate (FIG. 1, *N*, *O*), with but a few having the spores arranged in a linear series. The number of spores per sporangium was quite small, ranging from four to sixteen in number.

From these results, it seems reasonable to assume that the width and general shape of the sporangia are not very stable and not completely determined by genetic causes, changing not only with the differences in the quality and quantity of the surrounding water, but also varying somewhat within a constant environment. Nevertheless, they have been used as the distinguishing set of factors in the description of three species distinct from the type *Brevilegnia*

[4] In temperatures below 10° C., no sporangia at all were produced, although the ends of the hyphae were swollen and distorted (FIG. 1, *P*, *Q*).

unisperma—namely, *B. linearis* Coker (**1**), *B. diclina* Harvey (**6**), and *B. subclavata* Couch (**5**) (cf. Table 1). When *Brevilegnia* C–2 was grown in relatively small amounts of water, *i.e.,* 10 cc. or less, at temperatures approximating 20°–25° C., the sporangia were of the type characteristic of *B. unisperma;* when grown in over one liter of water, they were of the type characteristic of *B. linearis;* when grown in water previously inhabited by maturing

TABLE 1

TO SHOW MAIN CHARACTERS DISTINGUISHING THE SPECIES AND VARIETIES OF *Brevilegnia*

Species and variety	Sporangia	Spore motility	Antheridia	Gemmae
B. unisperma ..	23–38×190–350 μ; blunt, slightly tapering	Present	Androgynous	Absent
B. unisperma var. *litoralis* .	15–29×140–220 μ	Present	Absent	Absent
B. unisperma var. *delica*...	94–682 μ in length; spores often in 1–2 rows	Frequently present	Absent	Absent
B. linearis.....	Of same thickness as hyphae, with spores in single row	Absent	Androgynous	Absent
B. subclavata...	30–100×108–140 μ	Absent	Androgynous	Absent
B. diclina	Spores sometimes in a single row; dense	Absent (later found by Couch)	Androgynous (few)	Absent
B. megasperma.	In a single row; rarely more than three	Present	Androgynous	Present

colonies of the same genus, they were of the type characteristic of *B. subclavata*; and when grown in moderate amounts of water, *i.e.,* about 100 cc., they were of the type characteristic of *B. diclina.*

INFLUENCE OF ENVIRONMENTAL VARIATIONS ON ZOÖSPORES.

When the writer first began his study on *Brevilegnia* C–2, although his studies were carried out in hanging-drops of pure, redistilled water, no motile zoöspores were observed. A few weeks later, however, with conditions as far as known the same, secondary zoöspores were seen emerging from their cysts. Ever since, for a period approximating a year, the normal life-cycle of the spores has been characterized by a period of swarming. Had the writer described the species when it was first studied, he would have typi-

fied it as a form in which zoöspores were lacking. Since then, it would have been described as a form which typically had motile spores.

Yet the rarity of the occurrence of motility was emphasizezd by Coker (**1**) in his description of *B. unisperma* var. *delica,* and the total absence by Harvey (**6**) in his description of *B. diclina,* although Couch (**5**), in subcultures of Harvey's *B. diclina,* found motility regularly present.

In general, the fundamental basis of activity of the zoöspores is little understood. It is known that certain conditions of the environment, such as the presence of oxygen and minimal concentration of organic and inorganic compounds, must be met in order that the spores may assume a swimming stage, but beyond that our knowledge of the mechanism is extremely slight. Hence, it is the writer's belief that until it is shown that zoöspore activity is influenced more by the genetic character of the organism than by the condition of the environment, species or varieties should not be separated because of the presence or absence of motility in the asexual swarmspores.

INFLUENCE OF STALING WATER ON GEMMA FORMATION.

In contrast with the condition in pure water in which no gemmae were produced, gemmae appeared in relatively large numbers on the mycelium of *Brevilegnia* C–2 when the fungus was grown in water containing concentrated staling products, resulting from the growth of twenty colonies of *Brevilegnia* C–2 for 14 days on hemp seed at 25° C. in 25 cc. of water subsequently filtered through a porcelain filter. The thin-walled, densely protoplasmic gemmae were formed either singly in an intercalary fashion (FIG. 3, *C*) or else terminally in chains up to seven gemmae in length (FIG. 3, *A, B, F*). In the latter case, they were not all of the same dimensions, but gradually tapered in size from the distal cell, which was up to ten times the diameter of the subtending vegetative hypha, to the extreme proximal one, which was generally from three to five times the diameter of the filament on which it was borne. No special attempts were made to germinate the gemmae, although some were seen giving rise to short hyphae.

Yet, despite the variation in gemma formation which environmental changes induced as shown above, *B. megasperma* was described by Harvey (**7**) as a distinct species because of the fact that under "normal" conditions gemmae appeared in large numbers (cf. Table 1). However, if this character of gemma formation

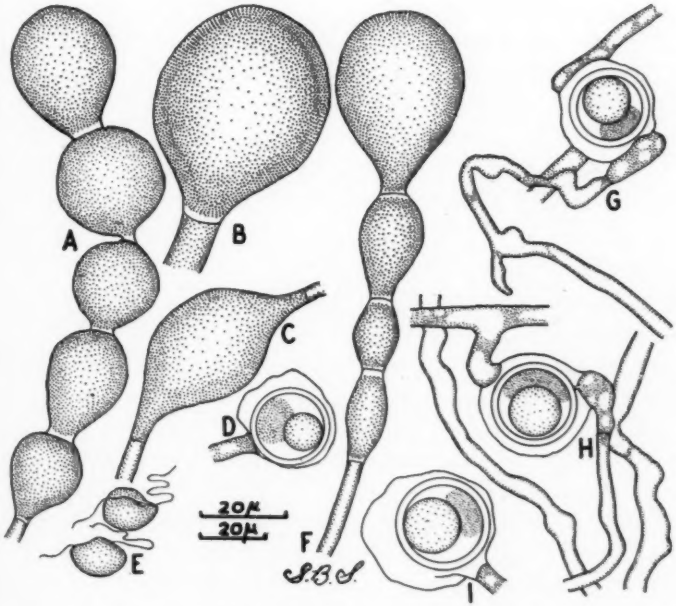


FIG. 3. Camera lucida drawing of gemmae, oögonia, and zoöspores of *Brevilegnia* C–2. (Cf. text for details.)

is partially dependent on the condition of the enveloping medium, its importance in the taxonomic treatment of the genus is greatly lessened. Hence, a species based on the presence or absence of gemma formation is somewhat doubtful.

INFLUENCE OF THE ENVIRONMENT ON ANTHERIDIUM FORMATION.

The most important environmental factor that stimulated or hindered the hypha in the formation of antheridia was the quantity of oxygen available. When a hemp seed inoculated with *Brevi-*

legnia C–2 was placed at the bottom of a cylinder of water 10 inches high and another seed floated on the surface of a similar depth of water in a second cylinder, there was a great difference in the number of antheridia in the respective positions. The mycelium on the surface of the column of water formed great numbers of

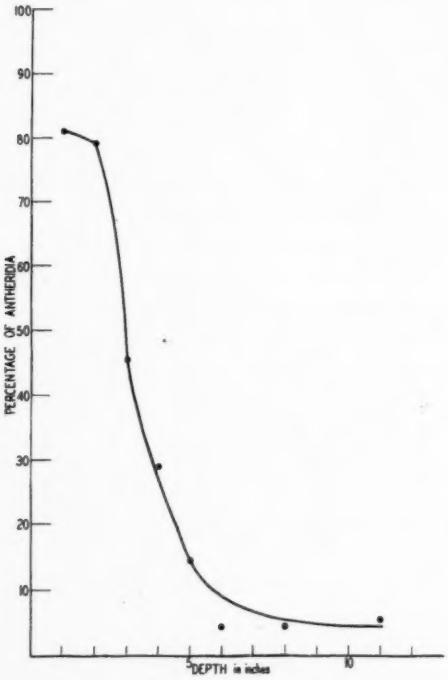


FIG. 4. Graph, showing the relationship between the percentage of öogonia with attached antheridia and the depth of water at which the mycelium developed.

irregular, contorted, hyaline, extensively branched, diclinous antheridia (FIG. 3, *G, H*), while the one at the base formed none (FIG. 3, *D, I*). Yet, even where antheridia were present, many mature oögonia lacked them, the indication being either that the antheridia were easily detached from the female after fertilization or that the oöspores developed parthenogenetically.

When mycelia were suspended in a 10 inch column of water at intervals of one inch, it was noted that the greater the depth at which the hyphae grew, the fewer the antheridia. Thus, at the surface of the water, 82 per cent of the oögonia had antheridia attached, while at the bottom only about 4 per cent (FIG. 4). The indication is that, in this genus, formation of antheridia is a function controlled not by the genetic constitution of the organism but rather by the degree of aerobiosis of the surrounding medium.

Nevertheless, Coker and Braxton (**3**) formed a new variety of *Brevilegnia unisperma, i.e.,* var. *litoralis,* chiefly on the character that antheridia were absent, whereas they were present in the species (cf. Table 1). According to the results obtained on *Brevilegnia* C–2, such separation of the two forms does not seem advisable.

DISCUSSION

The most important character that is used as a key in determining a genus in the Saprolegniaceae is the type of asexual reproduction—that is, the form of the sporangial development, the mode of zoöspore formation, and the extent of the swarmer cycle. In addition, there may be other minor distinguishing properties which may involve a particular manner of sexual reproduction or the extent of vegetative growth. For example, the genus *Geolegnia* is usually marked by a dense, rather limited mycelium, and the species of *Dictyuchus* have mostly a one-spored oögonium. But such characters are of secondary rather than primary significance, and should not be used alone as the main factor in the separation of a genus.

Hence, the main delimiting characters in *Brevilegnia* and the ones which show the minimum amount of variation are the type of sporangial wall and the manner of spore liberation. Except when the sporangia are uni- or biseriate, the spores are liberated not "about as in *Thraustotheca*" (**1**), but exactly as in *Thraustotheca.* When the sporangia are one or two spores wide, the zoöspores emerge directly from their cysts within the sporangium, resulting in a net-like appearance, as in the genus *Dictyuchus.*

According to Coker et al., the wall of the ruptured *Brevilegnia* sporangium gradually disappears. However, the writer has found evidence to the contrary. Several sporangial fragments over a

week old were killed and stained with chloriodide of zinc, and when examined under a magnification of 1140, a thin sporangial wall was clearly visible. These thinned remnants of the original sporangial wall partially enveloped the groups of spores and undoubtedly in part constituted the structure that prevented those spores within the sporangium from spreading freely through the water and restrained them in groups of varying sizes.

The mechanism for the distribution of the spores of *Brevilegnia* is thus the same as that in *Thraustotheca,* except that in the former the sporangial wall is thinned and weakened to a much greater degree. Since there are no marked differences between *Brevilegnia* and *Thraustotheca,* the evidence indicates that the genus *Brevilegnia* should be reduced to a subgenus under *Thraustotheca.*

The two subgenera would then be separated on the relative thickness of the sporangial wall and the degree to which it disintegrates into various portions partially enveloping the spore masses. The subgenus *Euthraustotheca* would include the species previously described under the genus *Thraustotheca,* whereas the subgenus *Brevilegnia* would contain those forms previously placed in the genus *Brevilegnia.*

Thus, the genus *Thraustotheca* (de Bary) Humphrey may be characterized as follows:

Hyphae stout to slender, branching. Sporangia clavate to subcylindric to very long, often irregular. Primary sporangia formed from swollen ends of hyphae; secondary sporangia proliferating by sympodial branching. Zoöspores when formed encysting within the sporangium and later, in more or less angular form, swelling and escaping (with the exception of those forms that possess sporangia with spores in a single or double row), by irregular rupture or disintegration of the sporangium wall, not escaping at once by an apical papilla except in the *Achlya*-like primary sporangia of two species. Spores escaping from their cysts to swarm in the laterally biflagellate form, to encyst again and finally give rise to a hypha of germination. Oögonia one to several spored with eccentric eggs; antheridia present or absent.

Subgenus *Euthraustotheca:*

Primary threads in greater part stout, branching. Sporangia clavate to subcylindric, often irregular, proliferating from below as in *Achlya;* spores always or in great majority encysting within

the sporangium when formed and later, in more or less angular form, swelling and escaping by irregular rupture or disintegration of the sporangium wall, not escaping at once by an apical papilla except in the *Achlya*-like primary sporangia of one species, *T. primoachlya*. Eggs eccentric, usually multiple. Antheridia present. (Adapted from Coker, 1937.)

Subgenus *Brevilegnia:*

Mycelium dense to spreading. Sporangia in the great majority behaving as in *Euthraustotheca*, the wall becoming very fragile and easily ruptured; in one species, *T. bispora*, sporangia of *Achlya* type also present; spores very variable in size and shape in the same culture, larger ones multinucleate, encysting in position except in the Achlyoid type, and only slowly separating after the disintegration of the sporangium wall; after encystment either emerging and swimming once (dicystic and monoplanetic) with great facility or with utmost difficulty (depending on the form and environment). Gemmae present or wanting. Oögonia small, with a single eccentric egg. Antheridia present or wanting (depending on environment), androgynous or diclinous.

The evidence also indicates the advisability of including *Brevilegnia unisperma* Coker & Braxton, *B. unisperma* var. *delica* Coker & Alexander, *B. unisperma* var. *litoralis* Coker & Braxton, *B. megasperma* Harvey, *B. subclavata* Couch, *B. diclina* Harvey, *B. linearis* Coker & Braxton, and probably *B. unisperma* var. *montana* Coker & Braxton in one species—*T. unisperma* Coker & Braxton. All these species, with the exception of *B. unisperma* var. *montana* in which the oögonial character has not been duplicated, have been approximated in both asexual and sexual features by exposing mycelium of *Brevilegnia* C–2 arising from a single zoöspore to several different external conditions.

At present, such characters as the type of antheridium (androgynous or diclinous), general morphology of the oögonium, or method of sporangial proliferation have not been proved to vary with external conditions, but appear to be genotypically determined. On the other hand, characters such as the size of sporangia, size of oögonia, or occurrence of antheridia, which may show either much variation or intergradation, may be the results of influences either not purely internal, or else unknown.

Thus far, the species *B. bispora* Couch has been purposely omit-

ted from the discussion because of its atypical swarmer cycle. Although distinct from all the other types of *Brevilegnia* in the possession of two types of sporangia, it is similar to *Thraustotheca primoachlya* Coker and Couch. The latter species was separated from the type because of the fact that both Achlyoid and Thraustothecoid sporangia were produced on the same mycelium, and frequently on the same hypha. *Brevilegnia bispora* differs from *T. primoachlya* chiefly in the following respects: absence of motile swarmers in the Thraustothecoid sporangia; presence of great numbers of gemmae, especially under unfavorable conditions; and formation of only one oösphere per oögonium. If one believes that the development of gemmae and the appearance of motile zoöspores are factors greatly influenced and partially determined by the environment, the essential differences between *Thraustotheca primoachlya* and *Brevilegnia bispora* lie in the fact that the former has from 1–16 oöspheres per oögonium, whereas the latter has only one; and the sporangial walls of the former are somewhat more durable and lasting. Therefore, the writer suggests that for the present both these species should be considered as very closely allied, yet distinct enough to be considered separate. If at some future date, forms are discovered which have an intermediate and intergrading number of oöspheres per oögonium, then both of these species should be combined into one.

The conditions under which a fungus grows in nature are quite different from those existing in the laboratory. In a natural environment, morphological variations frequently occur due to the changes in the amount and nature of other proximate organisms, in the range of temperature, in the relative quantity of oxygen, etc. However, under carefully controlled laboratory conditions, variations can be reduced to a minimum. Only then may the properties of a species be determined and described, since comparative studies can be conducted with reasonable certainty.

SUMMARY

The genus *Brevilegnia* was established by Coker on the basis of the following characters: (1) the presence of a depauperate dense mycelium; (2) the development of zoösporangia which discharged the spores by the irregular rupture of a sporangium wall that dis-

appeared after maturity; (3) the variability in sporangiospore size and the frequent suppression of motility; and (4) the formation of small, monosporic oögonia. The species and varieties were separated from one another because of such properties as the size and shape of the zoösporangia, the presence or absence of antheridia, the motility or lack of motility of the zoöspores, and the formation or absence of gemmae.

These specific and varietal characters, however, were greatly influenced by the environmental conditions. The width and general shape of the sporangia changed not only with the differences in the quality and quantity of the surrounding water, but also varied somewhat within a constant environment. Zoöspore activity is too little understood to be used as a character for the delimitation of a species or variety. Gemma formation is partially dependent on the condition of the enveloping medium, whereas the appearance of antheridia is controlled by the degree of aerobiosis of the surrounding water.

In addition, the sporangia dehisced exactly as in *Thraustotheca* with fragments of the outer wall persisting throughout. Hence, *Brevilegnia* was placed as a subgenus under *Thraustotheca,* and all the species except *T. bispora* included under *T. unisperma.*

BIOLOGICAL LABORATORIES,
HARVARD UNIVERSITY,
CAMBRIDGE, MASS.

BIBLIOGRAPHY CITED

1. **Coker, W. C.** Other water molds from the soil. Jour. Elisha Mitchell Sci. Soc. **42**: 207–226. 1927.
2. ——. North American Flora. N. Y. Bot. Garden. 1937.
3. —— **& H. H. Braxton.** New water molds from the soil. Jour. Elisha Mitchell Sci. Soc. **42**: 139–147. 1926.
4. —— **& J. N. Couch.** Revision of the genus *Thraustotheca,* with a description of a new species. Jour. Elisha Mitchell Sci. Soc. **40**: 197–202. 1924.
5. **Couch, J. N.** Some new water fungi from the soil, with observations on spore formation. Jour. Elisha Mitchell Sci. Soc. **42**: 227–242. 1927.
6. **Harvey, J. V.** *Brevilegnia diclina* n. sp. Jour. Elisha Mitchell Sci. Soc. **42**: 243–246. 1927.
7. ——. A taxonomic and morphological study of some members of the Saprolegniaceae. Jour. Elisha Mitchell Sci. Soc. **45**: 319–332. 1930.

THE MORPHOLOGICAL DISTINCTION BETWEEN UROCYSTIS GLADIOLI AND PAPULASPORA GLADIOLI [1]

H. H. Hotson [2]

(WITH 3 FIGURES)

Although, Requien (cf. Duby (**3**)), in 1830, in France, had described a disease of *Gladiolus* as a rust, *Uredo Gladioli,* the correct determination was not made until 1876 when Worthington G. Smith (**11**), in England, described what was apparently the same fungus on *Gladiolus communis* as a smut disease, *Urocystis Gladioli.* He justly recognized that the sporeballs were clearly related to the smut *Thecaphora* although they greatly resembled the imperfect fungus, *Papulaspora.* However, having secured the opinion of Wittmark and Magnus and of Brefeld, the smut authority, Smith decided that he was correct in placing it in the genus *Urocystis.* In referring to the disease he stated that it was "most virulent in damp, heavy soils" during the wet seasons and that the bulbs seemed to be attacked while in the ground.

In Great Britain, since the work by Smith, Massee (**5**) recorded it, in 1906, at Kew, Surrey, and in a later article (**6**) described the sporeballs as 40–50 μ in diameter. Pethybridge (**8**) stated that it occurred in Somerset, in 1923; in Yorkshire, in 1932; and, in 1936, on the variety of *Gladiolus nanus,* Peach Blossom, in Devonshire. Moore (**7**), in 1939, included this fungus in his book on the diseases of bulbs, as a rare disease giving a description and some control measures.

In Continuental Europe, Wallroth (**12**), in 1833, in Germany, recorded it as *Erysibae arillata* var. *Gladioli* (Req.) Wallr., while van Poeteren (**10**), in 1923–24, found it in Holland on *Gladiolus*

[1] Contribution from the Laboratories of Cryptogamic Botany and the Farlow Herbarium, Harvard University, no. 195.

[2] The author wishes to take this opportunity to express his sincere appreciation to Dr. Wm. H. Weston, Jr., for his guidance and constant inspiration.

nanus especially on the variety Peach Blossom. Winter (**14**), in Die Pilze, in 1881, described this fungus and stated that it was found on *Gladiolus communis* and *Gladiolus imbricatus*. A brief description was given by Pape (**9**), in 1927, in Germany, in which he reported the disease on *Gladiolus communis, G. nanus, G. imbricatus, G. segetum,* and *G. bucheanus* (?), also stating that it had been reported from England, Holland and France. He stated that the disease showed symptoms on the stalk or rhizome in the form of black pustules or blisters which raised the epidermis. J. I. Liro (*i.e.* J. I. Lindroth) (**4**), in 1922, called it *Tuburcinia Gladioli* (Req.) Liro, basing this change on his conception of the genus *Tuburcinia* Fries in which he included many species previously in *Urocystis*. Thus, the synonomy, if we accept *Urocystis Gladioli* (Req.) Smith as the proper name, is *Uredo Gladioli* (Req.), *Erysibae arillata* var. *Gladioli* (Req.) Wallr., *Tuburcinia Gladioli* (Req.) Liro.

In the United States, C. C. Wernham (**13**), in 1938, in Pennsylvania, isolated from *Gladiolus* sp. a fungus which he called *Urocystis Gladioli* (Req.) Smith, but which, unlike smuts of that genus, germinated readily to mycelium on potato-dextrose agar. Zundel (**15**), in 1939, reported *Urocystis Gladioli* (Req.) Smith, in Erie Co., Pennsylvania, on *Gladiolus* sp. (cult.). He also reported it from the Province of Saskatchewan, Canada. Since both men reported the same disease, caused by the same fungus, from the same locality, the fungi probably may be assumed to be identical even though Zundel does not mention germinating the sporeballs in culture. B. O. Dodge and Thomas Laskaris (**1**), in 1941, isolated what they thought to be the smut disease of *Gladiolus* from diseased bulbs from Long Island, N. Y., and, doubting that it was a smut, stated that this fungus seemed to be a *Papulaspora.* In a later paper (**2**) they determined this was a *Papulaspora* but thought it the same as the European material, even though they were unable to compare them. Nevertheless, they called their fungus *Papulaspora Gladioli* (Req.) Dodge and Laskaris. They add: "If Requien's type is a leaf smut the combination would simply be *Papulaspora Gladioli* (Smith)." The writer, however, assumes on the basis of evidence presented here that Smith's material is the same as Requien's.

Now, the writer has been able to make the necessary comparison of these two organisms, *Urocystis Gladioli* (Req.) Smith and *Papulaspora Gladioli* (Req.) Dodge and Laskaris, and, as a result, is convinced that they are two separate entities. The evidence for this conclusion is presented in the following paper.

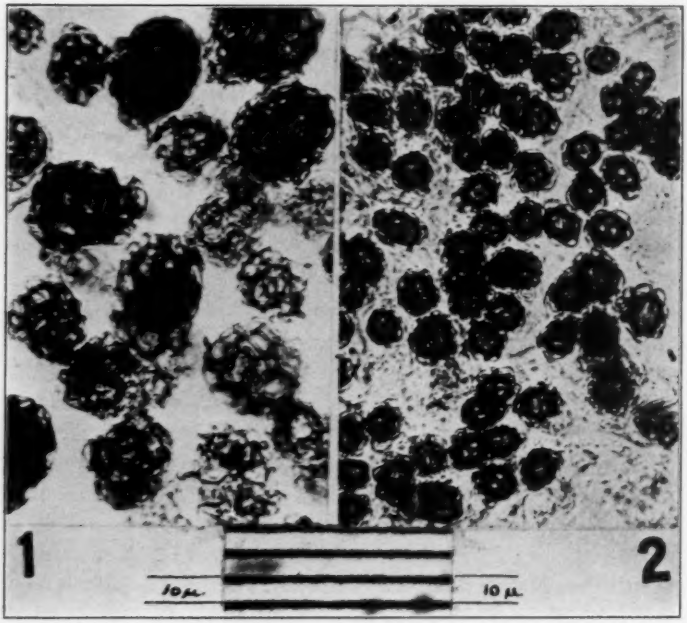


FIG. 1. Sporeballs of *Papulaspora Gladioli;* 2, Sporeballs of *Urocystis Gladioli.* Both at the same magnification. (400 ×.)

Culture material of *Papulaspora Gladioli* from the laboratories of B. O. Dodge plus some additional isolations of *Papulasporas* from diseased corms of *Gladiolus* from Long Island, N. Y., comprise the material upon which the writer has based this comparative study. The European material, from collections by G. H. Pethybridge, in Langeport, Somerset, England, in 1923, was made available through the courtesy of E. M. Wakefield of the Royal Botanic Gardens at Kew. From this material, originally pickled when col-

lected in 1923, a small portion was dried and sent the writer in 1941. This was prepared in glycerine mounts for study, while the American material was grown in culture and studied both living and in glycerine mounts.

On critical examination, the most important structure, the sporeballs, were found to be in sufficiently good condition in this English material, for adequate comparison with the American material. The following distinction, as seen in figure 1, are at once apparent. First, the sporeballs are distinctly different in size; *Urocystis Gladioli* measures from 14–23 μ in diameter while *Papulaspora Gladioli* has the extreme ranges of from 24–64 μ in diameter with the average at 44 μ (FIG. 3). This, in itself, is not significant unless one considers the variation in size. The European material has been reported in the literature as ranging from 40–50 μ in diameter with the average at approximately 45 μ, while the specimen of *Urocystis,* received from England, is confined within much narrower limits. Second, the definiteness of the sterile perifera of *Urocystis Gladioli,* as shown in figure 2, is more striking than that of *Papulaspora Gladioli.* In *Urocystis Gladioli,* the single row of thin-walled cells is characteristic of the genus and the definite thickness of the wall of the inner cell is very distinct. In *Papulaspora Gladioli,* on the other hand, the perifera is not always sterile and is more or less indefinite, being often composed of more than one layer of cells, indefinitely and irregularly arranged. Finally, the central cells in the *Urocystis* range from 1–2 in number while those in the *Papulaspora* are customarily 2–6 or, exceptionally, 6–8 in number.

Due to the fact that the European material has been preserved for nearly eighteen years, certain of the morphological characters unfortunately are valueless for this comparison. The mycelium has degenerated and as the material is not living a germinative study cannot be made.

Even more significantly different than the foregoing morphological distinctions are the unlike reactions of these two fungi on the host. As was mentioned above, *Urocystis Gladioli* causes, on the stalk and rhizome, black pustules which contain the sporeballs of the smut. The symptoms are clearly those of a smut. On the other hand, *Papulaspora Gladioli* is found as a saprophyte in the

cracks in the corms as arachnoid mycelium bearing the discernible bulbils.

Hence, in Europe, there seems to be an organism, *Urocystis Gladioli* (Req.) Smith, which attacks the corms and stalks of several species of *Gladiolus* causing blisters or pustules filled with sporeballs. The disease was very bad in England, according to

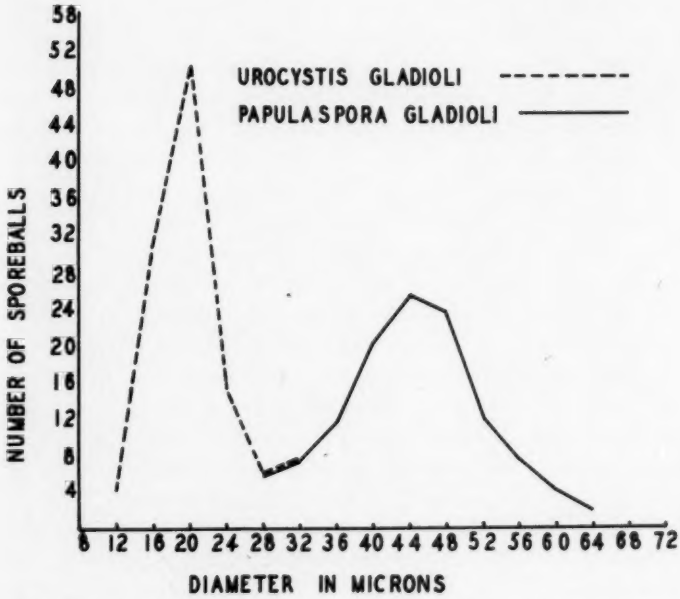


FIG. 3. Graph showing relative sizes of sporeballs of *Urocystis Gladioli* and *Papulaspora Gladioli* each based on 200 sporeballs measured at random.

Smith, but has been gradually decreasing in severity until, in 1939, Moore spoke of it as rare. In the United States, there is a fungus, *Papulaspora Gladioli,* which is not parasitic or only slightly so, and does not cause pustules or blisters on the corms or stalks, but is found in the cracks of diseased *Gladiolus* bulbs which have already been infected by some other organism.

Such being the case, this *Papulaspora* on *Gladiolus* is not a synonym for *Urocystis Gladioli* (Req.) Smith, as the two are distinct.

It seems necessary, therefore, in view of the confusion, to establish it as a separate entity. An excellent diagnosis has been recently published by B. O. Dodge and T. Laskaris (2) so that it is unnecessary to repeat it here.

Papulaspora Gladioli sp. nov.

For complete diagnosis see the article by B. O. Dodge and T. Laskaris (2). In addition it may be noted that the average diameter of the bulbils is 44 μ and the bulbil primordium is a lateral branch, sometimes coiled in one plane but never a spirile.

In view of the existing confusion between these two fungi, any conclusions must at present be based on certain assumptions.

Assuming that Pethybridge's material is the same as that of W. G. Smith's and that they both are the same as Requien's, then it seems that there exists a true smut disease, *Urocystis Gladioli* (Req.) Smith, in Europe, and that this has not been reported in the United States. The identification by W. G. Smith seems dependable since he consulted three outstanding mycological authorities prior to publication, and the possibility that Brefeld would not know a *Urocystis*, after his extensive studies in this group, seems unlikely, particularly when he was confronted with the possibility that it might be either a *Papulaspora* or a *Tuburcinia*. There is some evidence, however, that in addition there may well be a *Papulaspora* in Europe which has been confused with *Urocystis Gladioli* for there are notable discrepancies in the published sizes of the European material in comparison with that of the material sent the writer from Kew. This also adds to the confusion and until someone is able to get type material of W. G. Smith's *Urocystis Gladioli* from the British Museum the significance of these differerences cannot be ascertained with certainty. The material which was thought to be the smut disease in this country is in reality various species of *Papulaspora*, as will be shown in a later paper. These American forms do not cause a disease but are merely saprophytes following a primary infection of some other fungus, often *Sclerotinia* (*Botrytis*) sp.

The evidence, therefore, seems to the writer sufficient grounds to justify the conclusion that these two fungi are separate entities

and that this European fungus on *Gladiolus* is a *Urocystis* while those in America are *Papulasporas*. Also, that *Papulaspora Gladioli* is a separate species, not one which has previously been described, and it is distinct from any of the species, subsequently described by the author, which will appear in a later paper.

However, until such time as living material of *Urocystis Gladioli* (Req.) Smith has been studied and a comparative life history worked out, the problem in its entirety must go unanswered.

BIOLOGICAL LABORATORIES,
HARVARD UNIVERSITY,
CAMBRIDGE, MASS.

REFERENCES

1. **Dodge, B. O. & Thomas Laskaris.** The smut disease of *Gladiolus*. Science **93**: 111. 1941.
2. ——. *Papulaspora Gladioli*. Bull. Torrey Club **68**: 289. 1941.
3. **Duby, J. E.** Botanicon Gallicum **2**: 901. 1830.
4. **Liro, J. I.** Über die Gattung *Tuburcinia* Fries. Ann. Univ. Fenn. Aboen. A. **1**: 37. 1922.
5. **Massee, G.** The wild fauna and flora of the Royal Botanic Gardens, Kew. Kew Bull. Add. Ser. **5**: 165. 1906.
6. ——. Diseases of cultivated plants and trees. p. 349. 2nd Ed. London. 1915.
7. **Moore, W. C.** Diseases of bulbs. Bull. No. 117. Min. Agric. Fish. London. p. 121. 1939.
8. **Pethybridge, G. H.** Report on the occurrence of fungus, bacterial and allied diseases of crops in England and Wales for the years 1922 to 1924. Misc. Publ. Min. Agric. Fish. London. **52**: 88. 1926.
9. **Pape, H.** Die Krankheiten und Schädlinge der Gladiole. *In* Sandhack. Dahlien und Gladiolen Berlin. p. 243–268. 1927.
10. **Poeteren, N. van.** Verslag over de werkzaamheden van den Plantenziektenkundigen Dienst in de Jaren 1923. Verslag Plantenziektenkundigen Dienst Wageningen **34**: 34. 1924, and Ib. **41**: 16. 1925.
11. **Smith, W. G.** The *Gladiolus* disease. Monthly Microsc. Jour. **16**: 304–311. 1876, also Gard's Chron. **6**: 420. 1876.
12. **Wallroth, F. G.** Fl. Crypt. Germ. **2**: 211. 1833.
13. **Wernham, C. C.** Chlamydospore production on artificial media by *Urocystis Gladioli*. Phytopath. **28**: 598–600. 1938.
14. **Winter, Geo.** Die Pilze. *In* Rab. Krypt.-Fl. 1^1: 121. 1884.
15. **Zundel, G. L. I.** Additions and corrections to Ustilaginales. N. Am. Flora **7**: 1016–1017. 1939.

PHACIDIUM NIGRUM

EDITH K. CASH

(WITH 1 FIGURE)

Among recent collections from Florida made by Dr. C. L. Shear and referred to the writer for determination were several specimens of a Phacidiaceous fungus on leaves of *Xolisma ferruginea* (Walt.) Heller which proved on examination to be identical with type material of *Phacidium nigrum* Cooke in the Mycological Collections of the Bureau of Plant Industry. Two additional specimens of the same species were also found in the Collections under another name. *P. nigrum* was described from material found by Ravenel in 1881 at Darien, Georgia, and except for Cooke's description in Grevillea (**1**, p. 23) and its translation in Saccardo, no reference in literature to its occurrence has been found. It seems desirable, therefore, to supplement the brief original description with further details.

On leaves and twigs of *Xolisma ferruginea,* scattered or densely crowded and forming a black crust; spots on leaf margins suborbicular or irregular, later covering a large part of the leaf surface, avellaneous [1] to sayal brown, later fading to drab gray, often shading to pale vinaceous drab or purple drab near the border; stromata in epidermal layer, cells of epidermis and central tissue of leaf disintegrated by mycelium; sterile stromata epiphyllous, scattered or crowded, partially emergent but usually remaining covered by the lacerate epidermis, fragments of which often remain attached by one edge in the form of a lid; apothecia developing singly from fertile hypophyllous stromata, scattered or grouped along the midrib and veins, or closely crowded and covering a large portion of the leaf, also often surrounding and incrusting the small twigs, elliptical in outline or irregular from mutual pressure, fleshy to carbonaceous, 1–2 mm. in diameter, surface dull black, roughened,

[1] Color nomenclature is that of Ridgway, R., Color standards and color nomenclature. Washington, 1912.

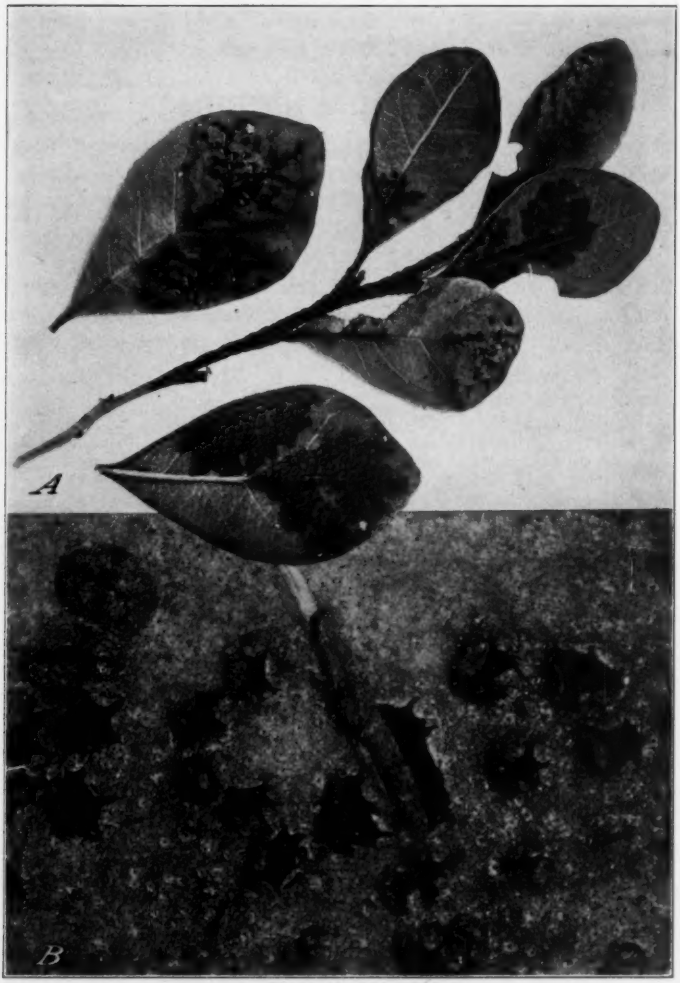


FIG. 1. *Phacidium nigrum* Cooke.

splitting in stellate clefts to expose the olive-gray, pruinose hymenium; asci clavate, gradually attenuated toward the base, broadly rounded at the apex, 120–130 × 13–18 μ; ascospores obliquely uniseriate below, irregularly 2–3-seriate above, unicellular, hyaline,

ellipsoid-clavate or ellipsoid-fusoid, sometimes slightly curved, at first surrounded by a hyaline gelatinous envelope, 26.5–30 × 4–6 μ; paraphyses numerous, hyaline, filiform, unbranched, longer than the asci, not enlarged at the apex, 1–1.5 μ diam.; hypothecium pale brown, 20 μ thick; underlying layer hyaline, subsclerotioid, 100–200 μ thick; covering layer dense, corky, black, 75–100 μ thick, splitting in the center. No spermagonial stage has been observed.

SPECIMENS EXAMINED:

Darien, Ga., 1881, H. W. Ravenel *3211*, ex herb. Ellis (part of type).
San Mateo, Fla., Dec. 24, 1909, T. R. Robinson.
Florida, Dec. 1, 1920, comm. C. V. Piper.
Orlando, Fla., Feb. 19, 1938, C. L. Shear.
Winter Park, Fla., Feb. 29, 1940 and Dec. 15, 1940, C. L. Shear.

The host is given in Cooke's description and on the label of the type specimen as *Andromeda* sp., but has been determined as *Xolisma ferruginea*.

The taxonomic position of the fungus presents some difficulties. The densely crowded apothecia, developing in stromata embedded within the leaf tissue, and the presence of sterile stromata on the reverse leaf surface are more characteristic of *Rhytisma* than of *Phacidium*. No swollen cells on the lower surface of the cover, such as are described and illustrated by Nannfeldt (**5**, pp. 246–247, f. 37-f) and v. Hoehnel (**2**, p. 317, f. 15) as an opening mechanism in *Phacidium lacerum*, have been observed in *P. nigrum*. The ellipsoid-clavate or ellipsoid-fusoid spores are intermediate in length between the short ellipsoid spores of most species of *Phacidium* and the elongate spores characteristic of *Rhytisma*. Nannfeldt has pointed out (**5**, p. 200) that *Rhytisma* spores are not truly acicular or filiform, as they have been described by various authors, but "langestreckt tränenförmig."

The fungus to which *Phacidium nigrum* bears the closest resemblance is *Rhytisma Curtisii* Br. & Rav., a species on *Ilex* leaves which is the type of the genus *Macroderma* v. Hoehnel (**3**, p. 419) and recently referred to *Phacidium* by Luttrell (**4**, p. 701). In the

fungus on *Xolisma* the stromata are smaller and more densely crowded than those in *P. Curtisii*, and fruiting stromata are confined to the lower leaf surface. Both fungi resemble *Rhytisma* in the presence of the sterile stromata on the opposite surface of the leaf from the apothecia, but differ from that genus in that apothecia develop from separate stromata. In *P. nigrum* the stromata are sometimes so densely crowded that they appear to be confluent, but remain distinct, each bearing a single apothecium. The asci of *P. nigrum* are clavate and strongly narrowed toward the base, resembling those of *Rhytisma Andromedae* rather than the more cylindrical asci of *P. Curtisii*. The spores are closer to *P. Curtisii* in dimensions and form, although somewhat longer, but the clustered arrangement in two or three rows toward the top of the ascus is again more like *R. Andromedae*. It is evident that the characters discussed at some length by Nannfeldt (**5**, pp. 240–243) and Luttrell (**4**), as indicating the intermediate position of *P. Curtisii* between *Phacidium* and *Rhytisma*, hold equally true for the fungus on *Xolisma*.

Characters noted by Theissen (**6**, pp. 265–7, fig. 1) and v. Hoehnel (**3**, p. 419) as a basis for the genus *Macroderma* have been shown by Nannfeldt (**5**, pp. 240–241) and Luttrell (**4**) to be either founded on erroneous observations or on points not sufficiently stable or significant to constitute generic distinctions. *P. nigrum* is therefore not here referred to that genus.

In spite of marked resemblances to *Rhytisma*, particularly *R. Andromedae*, and the presence of characters not observed in the type of *Phacidium*, it seems advisable to leave the species, at least for the present, in the latter genus in which it was described by Cooke.

Grateful acknowledgment is made to W. Lawrence White for consulting records of the Farlow Herbarium for references to *P. nigrum*, and to Cornelius H. Muller of the Bureau of Plant Industry, for identifying and verifying the host of the specimens studied.

BUREAU OF PLANT INDUSTRY,
WASHINGTON, D. C.

LITERATURE CITED

1. **Cooke, M. C. & Harkness, H. W.** Discomycetes of California. Grevillea **13**: 22–23. 1884.
2. **Hoehnel, F. von.** Fragmente zur Mykologie no. 1011. Sitz.-ber. Akad. Wien **126**: 314–322. *illus.* 1917.
3. ——. System der Phacidiales v. H. Ber. Deutsch. Bot. Ges. **35**: 416–422. 1917.
4. **Luttrell, E. S.** Tar spot of American holly. Bull. Torrey Club **67**: 692–704. *illus.* 1940.
5. **Nannfeldt, J. A.** Studien über die Morphologie und Systematik der nicht-lichenisierten inoperculaten Discomyceten. Nova Acta Soc. Sci. Upsala IV. **8**^{2}: 1–368. *illus.* 1932.
6. **Theissen, F.** Verschiedene Mitteilungen. Ann. Myc. **14**: 263–273. *illus.* 1916.

EXPLANATION OF FIGURE

FIG. 1, *A, Phacidium nigrum* on *Xolisma ferruginea* from Florida, showing discoloration and sterile stromata on upper leaf surface (upper detached leaf at left) and apothecia on lower surface (detached leaf below), × 1¼; *B,* apothecia on lower surface of leaf, × 10. (Photographic negatives by M. L. F. Foubert.)

TYPE STUDIES ON BASIDIOMYCETES. I

R. SINGER [1]

ASTROGASTRACEAE

HYDNANGIUM SODERSTROMII Lagerheim ap. Lag. & Pat. Bull. Soc. Myc. Fr. **9**: 142. 1893.

A specimen belonging to the collection which was distributed by Lagerheim and collected "zwischen *Eucalyptus*-Wurzeln, Quito, Ecuador." This species is macroscopically identical with *H. carneum* growing in numerous individuals in the earth near the roots of *Eucalyptus* and *Melaleuca* in the Botanical Gardens of Europe and North America (Cambridge, Mass.; Leningrad, U. S. S. R. etc.) and generally considered to be the most typical representative of this heterogeneous genus. Spores 14.5–15 × 12.5–14 μ, subglobulose with about 2 μ long spines the tops of which are amyloid.

Conclusion: H. Soderstromii Lagerheim = *H. carneum* Wallr.

BOLETACEAE

PULVEROBOLETUS RAVENELII (Berk. & Curt.) Murrill, Mycologia **1**: 9. 1909. *Boletus Ravenelii* Berk. & Curt. Ann. Mag. Nat. Hist. **2**: 429. 1853.

Investigable specimens of this species were carefully compared with the specimens of Curtis and of Murrill. One collection (Alabama, coll. Earle) shows the following characters: true veil present, cortinoid, composed of thin colorless filaments. The bright yellow color is due to yellow cristalline bodies. No clamp connections seen. *Spores* are ovoid-cylindrical or subfusoid, strongly colored (brown) 10–12 × 5–6μ. Q = 2; *basidia* 4-spored, clavate, 25–32 × 11 μ; *cystidia* hyaline or brown, fusoid or subclavate, with a short and thin apiculus, 36–47 × 7–10.5 μ; *trama* of the tube walls of the *Xerocomus*-type, *i.e.*, not truly bilateral.

[1] Contribution from the Laboratories of Cryptogamic Botany and the Farlow Herbarium, Harvard University, no. 199.

Conclusion: For those who prefer larger genera (like *Gyrodon* including *Boletinellus* and *Paragyrodon*) it may be recommendable to include *Boletus Ravenelii,* and perhaps the whole *Pulveroboletus*-group, as a subgenus in the genus *Xerocomus* from which it does not differ actually except for the rather peculiar veil. Those who accept genera based chiefly on the presence of a veil may prefer to recognize the genus *Pulveroboletus* Murr.

PHYLLOPORUS ROMPELII Pat. & Rick, Brotéria **6**: 81. *pl. 6, fig. 1.* 1907.

I compared a well preserved specimen collected by D. H. Linder in British Guiana with originals of Rick from Rio Grande do Sul, Brazil. Both are identical in all regards. The *spores* are ellipsoid to almost reniform, 8–9.8 × 5–5.8 μ, smooth, fairly well colored (brown); *basidia* 26–45 × 7.2–10 μ, 4-spored, and with sterigmata 7 μ long; *cystidia* near the pore mouths fusoid, bottle-shaped or subulate, small, 15–17 × 4 μ, neck 2 μ in diameter; *hyphae* with clamp connections.

Conclusion: There cannot be any doubt that *P. Rompelii* has all essential characters of the genus *Gyrodon.* As stated formerly (Rev. Myc. **3**: 172. 1938) this tropical species is closely related to *Gyrodon merulioides* (Schwein.) Sing. (= *Boletinus porosus* Peck). Smaller species of the latter are undistinguishable from *G. Rompelii.*

GYROPORUS SUBALBELLUS Murrill, N. Am. Flora **9**: 134. 1910. Type.

The *spores* are cylindrical-ellipsoid, hyaline, with rather thick walls, smooth, 7.5–10 × 4–5.5 μ (thus larger than indicated in N. Am. Flora). The thick-walled *hyphae* of the wooly surface of the pileus and the hyphae of the trama are hyaline and provided with clamp-connections.

Conclusion: All typical species of *Gyroporus* have clamp connections, according to my investigations. Thus, *G. subalbellus* is a good *Gyroporus,* very closely related to *G. cyanescens,* from which it differs according to Murrill's description in having unchangeable context and hollow stipe.

JUGASPORACEAE

OMPHALIA GIOVANELLAE Bres. Fung. Trid. **I**: 9. *pl. 5, fig. 2.* 1881. Coll. and det. Bresadola, Gocciadoro pr. Trento, locis herbidis, July, 1899.

Spores 6.5 × 3.8 μ, with some very slight longitudinal ridges, are fusoid, hyaline, with a distinct hilar depression, not amyloid; *basidia* up to 25 × 8.3 μ; *cystidia* none; *gill trama* somewhat intermixed; *hyphae* of the surface of the pileus 2–6 μ in diameter, all without clamp connections. The *lamellae* of the dry plant are dark, dull yellow. The carpophores grew directly on the earth. *Pileus* slightly eccentric in some specimens.

Conclusion: Like some other "Omphaliae" and "Pleuroti", for example *Pleurotus Passeckerianus,* recte *Clitopilus Passeckerianus* (Pilát) Josserand, *Omphalia Giovanellae* is a typical representative of the Jugasporaceae. All species of this family seem to be homothallic (cf. Kühner et Vandendries, Rev. Cyt. et Cytophys. Veg. 2 (3): 6) and this is the reason for the absence of clamp connections in all species studied by modern authors. (I studied personally *C. variabilis* sens. Fayod, *C. Passeckerianus, C. mutilus* sens. Lange, *C. prunulus.*) The typical Omphaliae have no clamp connections either, as I could state for *O. umbellifera, philonotis* and allied species, but their spores are always smooth and white. The spore print of *C. Giovanellae* is expected to be pinkish. *C. Giovanellae* belonging to the Jugasporaceae, another question arises concerning the limits of the genera *Hexajuga* and *Octojuga,* established by Fayod. It seems to me now that Maire and Josserand are right in uniting the smaller and the bigger forms into one genus and using for it the Friesian name *Clitopilus.* Thus *Omphalia Giovanellae* becomes: *Clitopilus Giovanellae* (Bres.) comb. nov. (*Octojuga Giovanellae* according to the older conception).

RUSSULACEAE

RUSSULA BALLOUI Peck, Bull. N. Y. State Mus. **167**: 31. 1913. Well prepared specimens from the type locality, September, 1915.

Spores 8.5–12 × 7.3–9 μ, asymmetrical ornamentation consisting of 0.8–1.1 μ high spines or somewhat shorter warts, type IIIa,

IIIb, sometimes VIII [2]; *basidia* 34–44 × 10–11.5 μ, 4-spored with sterigmata 5–8.7 μ long; *cystidia* with a rounded top, upper part with banded contents, 36–64 × 8.5 μ. Warts of the pileus now brown, consisting of an irregular texture of cylindrical hyphae, which are 4–5.3 μ thick, brown-yellow in NH_3, often septate or with plasma-bridges, with membrane-pigment. The next deeper stratum consists of transversally arranged normal hyphae with non or moderately thickened membranes, 2–4.6 μ thick with about 1.7 μ thick end-links having acute tops. In this part of the cutis there are laticiferae of 4–9 μ diameter. The margin is involute for a long time, subacute (± 90°) absolutely even, although thin. The veil fragments form a crust on the center of the pileus, and areolae towards the margin. The same fulvous brown areolae are found on the base of the stipe. Lamellae not anastomosing.

Conclusion: R. Balloui belongs to the subsection Fistulosinae Heim. It is distinguished by the anatomical characters of the cutis and the spore ornamentation. The analysis of the cutis by J. Schaeffer seems to be wrong or belonging to another species.

RUSSULA INSIGNIS Burl. N. Am. Flora **9**: 212. 1915, non Quél. (1887).

This collection is not the type but it is determined by G. S. Burlingham and fits perfectly the diagnosis. *Spores* 7.2–10.2 (–12.5) × 6.5–7.7 μ, echinulate; *basidia* 32 × 12 μ; *cystidia* 50–85 × 4–12.8 μ, with granulate or banded contents, very numerous at the edge; *epicutis* of the pileus with thin-walled, partially hyaline, partially yellowish brown, septate, subulate or clavate hairs with blunt tops, 8–13 μ in diameter.

Conclusion: This species has nothing to do with the somewhat dubious species of Quélet. I have therefore proposed the name *R. Burlinghamiae* Sing. Bull. Soc. Myc. Fr. **54**: (*2*) : 134. 1938. It belongs to the same group as the preceding species.

[2] For explanation of the figures marking the different types of spore ornamentation in Russulae and Lactarii see Beih. Bot. Centralb. **49** (*2*) : 218–220. 1932, or Bull. Soc. Myc. Fr. **51** (*2*) : 303–304. 1936.

RUSSULA MUSTELINA Fries sens. Bres. Icon. **9**: 403. *pl. 403.* 1929.

The figures of *R. mustelina* given in the Iconographia were considered as rather dubious. In this connection it is interesting to note that the original material sent by Bresadola to the N. Y. Botanical Garden is *R. mustelina* Fries sens. Melzer & Zvára (*R. elephantina* Fries sens. Sing.).

RUSSULA EARLEI Peck, Bull. N. Y. State Mus. **67**: 24. 1903. Type collection.

The *spores* are ellipsoid, 5–8.5 × 4–5.5 μ, mostly 6.8–7.5 × 5–5.5 μ, ornamentation 0.3–0.4 μ high, type VI, rarely VI–VIII, IV, hyaline in ammonia, asymmetrical truly verrucose in spite of the reduced height of the warts in iodine; *cystidia* of the edge 34–50–80 × 4.3–6.8 μ, cylindrical, with few granulae in the top or in the middle part, rarely the whole upper part with content; *basidia* 46 × 7.5 μ; *gill trama* chiefly vesiculose with scattered normal hyphae and laticiferous vessels of 5–10 μ in diameter. The cuticle of the pileus consisting of more or less interwoven but tangential hyphae; these hyphae are rather long and 2–7.5 μ broad, and lie loosely in a mucilaginous layer. Some of them ending in hair-like bodies, which are clavate or contracted in the middle, 3–8.5 μ broad; *dermatocystidia* none.

Conclusion: This characteristic species belongs to the subsection *Elephantinae*. It has some common characters with the subsection *Foetentinae*.

RUSSULA THEISSENII Rick, Brotéria **6**: 74. 1907. Specimens determined and distributed by Rick 1930 and 1931.

The *spores* are coarsely warted, hyaline in NH_3, asymmetrical, 8.5–10.5 × 7.5–8.3 μ, ornamentation 0.2–0.9 μ high, type IIIa, sometimes IIIb; *basidia* 35 × 13.5 μ; *cystidia* 75 × 16.5 μ. The pileus is without true dermatocystidia, but with thickened cystidia-like and often septate ends of hyphae. Surface staining brown with KOH. The villose margin is no longer evident in these specimens. Lamellae not regularly alternating. The indication of yel-

low spores in the original description may be explained by the presence in the hymenium of yellow amorphous incrustations.

Conclusion: This species seems to be intermediate between *Elephantinae* and *Foetentinae*.

RUSSULA VENTRICOSIPES Peck, Bull. Torrey Club **29**: 70. 1902. Type.

Type material studied by me in the New York Botanical Garden is identical in every respect with a collection from Toms River, N. J. (Murrill, *Tricholoma equestre*) and with a rich collection of fresh material in all stages of development from Wellfleet, Mass. (D. H. Linder). The following description is a combined description of the above mentioned materials:

Pileus reddish in the primordia, very soon changing to pale brownish and then to brown (exactly in the colors of *Russula foetens* and its varieties), with a darker center or unicolorous, frequently with an innate fibrosity like *Russula foetens* or *pectinata*, otherwise smooth and glabrous, hemisphaerical with a shallow umbilicus which develops to an infundibuliform depression, the margin remaining convex or the whole plant becoming concave at last, 42–80 mm. broad; *margin* strongly involute, adpressed to the stipe, later more straight and becoming shortly (4–7 mm.) and tardily but decidedly and constantly sulcate, not tuberculate, acute; *cuticle* rather thick, hard and firm, very viscid when fresh and wet with needles adhering on the surface, later merely humid or almost dry, not shining or slightly to strongly so on the margin, when dry, not separable except on the outer third. In SV [3] only a small number of the hyphae of the cutis turn blue to black and only a few of these reaching the scarcely developed epicutis are cystidia-like, showing very scattered blue granulae and ending with a broadly rounded apex, about 4.5 μ diam. The non-reacting hyphae are about 1.5 to 4 μ thick, thin-walled (walls up to 0.5 μ), passing through a gelatinous mass, very loosely in the epicutis and more densely and radially arranged in the subcutis, many of them undulate and not always cylindrical. Under the subcutis is a sur-

[3] The sulfovanillinic reagent (SV) used is that of Maire (Bull. Soc. Myc. Fr. **26**: 51. 1910), but with less water. It must be freshly prepared each time the reaction is made.

prisingly abrupt line separating the cutis from the trama, the latter being non-gelatinous and showing masses of laticiferae and sphaerocystae. Therefore the cuticular part separates easily from the flesh in preparations and they first swell up strongly if previously dried. KOH: darker brown. Other reagents without effect. *Lamellae* whitish, later cream-colored, very close to crowded, brittle, narrow as in *Russula foetens* or extremely narrow (2–5 mm. broad), edge red, later concolorous or more often brown, entire, a few lamellulae present and also a few forked ones, but never regularly forked, adnexed or attenuate-free to subdecurrent. When the pileus is still closed in an early stage of development, the lamellae leave a hole between themselves and the upper part of the stipe. In this period the edge of the lamellae is fimbriate from cheilocystidia of different shapes, but mostly drawn out into a short neck or button-like appendiculus, $50 \times 5–8\ \mu$. Their upper part is frequently wrapped in an amorphous reddish-brownish mass or incrusted by an intercellular pigment (in NH_3), causing the red color of the edges and of the stipe. Young lamellae staining reddish brown with aniline and becoming slate grey to bluish grey around the stain. In the mature stage the same kind of cheilocystidia are seen. The *basidia* are $40–50 \times 6.7–7.8\ \mu$, with 2 or 4 sterigmata which are $6–8\ \mu$ long; *cystidia* extremely frequent, equally on edge and sides of the lamellae, $42–85 \times 5–8.5\ \mu$, yellow in NH_3, dark reddish brown in iodine, blackish blue in SV but rarely with banded content, not granulate, acute or obtuse, in shape like the cheilocystidia (which, however, are not pseudoamyloid); most of them do not reach the level of the sterigmata but they arise deep in the trama and thus are true pseudocystidia. The *spores* are discharged from the young closed hymenophore mostly round, later the majority of them become ellipsoid or even subcylindrical, with or without a hilar-depression (in the latter case only flat at the inner side), $8–10 \times 4–5.5\ \mu$, in other specimens $9–11 \times 5–7\ \mu$, in the type specimen (fully mature) $5–9.5 \times 2.5–6.8\ \mu$, and with ornamentation $0.1–0.2\ \mu$ high, of type VI–VII, also III–VII; spore print B [4]; *subhymenium* vesiculose, well devel-

[4] The spore print color is described in accordance with the scale of Crawshay, C. The spore ornamentation of *Russula*, London, 1930.

oped; *trama* narrow, intermixed with numerous lacticiferous vessels (about 5–6 μ thick) and sphaerocysts (13–16 μ broad); normal hyphae rather frequent. *Stipe* red, "Light Jasper Red" to "Light Coral Red" (Ridgway), later the reddish color mixed up with pale brownish, and in the mature plant the red tint mostly disappearing and the whole stipe becoming concolorous, minutely granular or spotted by coarse brown granulae, but more often smooth, never pruinose, ordinarily tapering from the top to the base but sometimes more ventricose or cylindrical and attenuate only at the base, solid, later often with 1 or 2 cavities. On the surface of the stipe are many hyphae turning dark blue in SV and some of them are cystidia-like. The granulae consist of fasciculate and, except for the pigmentation, non-differentiated hyphae; they are filled by a deep ochraceous brown pigment solution and incrusted by a similar brown intercellular pigment. The mycelium, according to D. H. Linder, is reddish. *Flesh* yellowish white, later brownish white with a purer white zone between the cortex of the stipe and the inner cylinder, turning more or less brownish in old specimens, particularly in the wounded places and in the stipe; firm, rather elastic. *Odor* like the odor of *Russula foetens* but much weaker and the component of nitrobenzol almost completely lacking. *Taste* slowly but very acrid and slightly bitter, very old specimens milder. With $FeSO_4$ the flesh becomes slowly and very faintly dirty grey but near the cortex, dirty reddish; with formaline there is no reaction; with Phenol a normal reaction to dark chocolate brown; with KOH it turns darker brown, where already brownish; with H_2SO_4 a dirty greyish, and finally with aniline it changes to lemon yellow.

HABITAT: In pine woods on sandy soil. August–September. Area: Eastern part of the United States.

Conclusion: This species has nothing to do with *Russula pulverulenta* but it belongs to the *R. foetens*-group: *R. foetens, Laurocerasi, deremensis, punctipes, ventricosipes.* It is quite singular in having a red intercellular pigment and oblong, punctate spores. These spores would not be distinguishable from *Melanoleuca*-spores if there were no shorter ones between them. *Melanoleuca* has much more in common with *Russula* than the Hygrophoraceae.

RUSSULA VIRIDELLA Peck, Bull. N. Y. State Mus. **105**: 41. 1906, non Sing. Ann. Myc. **33**: 316. 1935. This collection is not the type but authentic material, collected and determined by Peck (Horicon, N. Y., July 22, 1905).

The *spores* are 6–7 × 5–6 μ, ornamentation 0.4 μ high with a very fine network, type IIIa, VII; *basidia* scattered between very numerous, large, fusoid, acute cystidia with an appendiculus and contents, about 85 × 14 μ. Upper layer of the cutis of the pileus consists of very numerous and conspicuous dermatocystidia of 9–12 μ diameter, among which are repent hyphae. In the subcutis, however, only repent hyphae are present. Sphaerocystae present merely in the trama.

Conclusion: This analysis seems to prove that my *R. viridella* from China is not identical with the original American *R. viridella* of Peck. Thus the former has to be called *R. yuennanensis* Sing. var. **pseudoviridella** Sing. nom. nov., the violet-lilac form (*R. yuennanensis* Sing. 1926 nom. nud. = *R. viridella* var. *yuennanensis* Sing. l. c., p. 317) representing the type of the Chinese species. *R. viridella* Peck is a good species closely related to *R. polycystis* Sing. All these species belong to the subsection *Virescentinae* which divides into three groups (stirpes):

A. Areolae consisting chiefly of hairs arising from an isodiametrical basal cell. *R. virescens* (Schff.) Fries, *crustosa* sens. lato, *chlorinosma* sens. Sing., *Patouillardii* Sing.

B. Areolae consisting chiefly of laticiferous elements. *R. viridella* Peck, *polycystis* Sing.

C. Areolae consisting chiefly of little or non differentiated hyphae. *R. schizoderma* Pat., *septentrionalis* Sing.

RUSSULA DURA Burl. Mycologia **16**: 19. 1924. "Ex-type."

The *spores* are 8.5–10.2 × 7–8 μ; ornamentation 0.6–1.0 μ high, type IIIa, some spores IIIb; *basidia* 43 × 7.7 μ with sterigmata 9.5 μ long; *cystidia* 61–80 × 10–12 μ, clavate-fusoid, very numerous, projecting 30–35 μ, with banded contents, not acute, but thinner near the top; *epicutis* of the pileus and the stipe consisting of hairlike hyphal ends of 2.5–4.5 μ diam., often thick-walled (wall

up to 1 μ), septate, some of them with cystidia-like contents, more often blunt on the pileus, more often acute on the stipe, arising from a subcutis of subparallel-interwoven tangential hyphae. No true dermatocystidia seen. Parts of the stipe are still beautifully light yellow.

Conclusion: This species is very near, perhaps too near to *R. ochroleucoides* Kauffm. Both of them form a transition between *Fistulosinae* and *Lepidinae.*

RUSSULA BLANDA Burl. N. Am. Flora **9**: 213. 1915. Type.

The *spores* measure 7–7.5 × 6–6.3 μ, hyaline and slightly rough in NH_3, ornamentation 0.2–0.4 μ high, type II, II–IV, IV, IIIb–VIII, warts blunt, short; *basidia* about 25 × 8–10 μ; *cystidia* not found, but probably present. *Trama* consisting of sphaerocysts and normal hyphae of about 3 μ diameter, some up to 9 μ diameter. The ends are often hair- or cystidia-like, obtuse, cylindrical, fusoid, subulate or clavate, without contents or surface incrustation (NH_3), rarely coarsely incrusted, often wavy-flexuose, rarely branched, 25–53 × 3–13 μ (primordial hyphae?). *Dermatocystidia* none. Flesh of the stipe brown with SV.

Conclusion: This species, found but once at the type locality, needs further observation and careful comparison with the European *R. lactea.*

RUSSULA PULCHRA Burl. Mycologia **10**: 95. 1918. The specimen seems to be part of the type collection or at least from the type locality: Stow, Mass.

The *spores* are slightly yellowish in NH_3, 8–11 × 6.5–9.5 μ, ornamentation consisting of long (1.0–1.7 μ) spines, type mostly VI, also VI–VIII, V, IV, II–IV; *basidia* 40–45 × 13.5–14 μ; *cystidia* clavate or fusoid, 55–70 × 9.3–12 μ, with content, showing long appendiculi, particularly the cystidia on the edge: appendiculi 8.5–10 μ long. *Epicutis* of the pileus without dermatocystidia, with primordial hyphae and hairs of about 12.5 × 3.5–7.5 μ. The cuticle is faintly warty under a lens.

Conclusion: R. pulchra is probably a representative of the *Lepidinae,* but it needs chemical investigation on the fresh plant, as it

is very distinct from other *Lepidinae* and microscopically reminding of the *Xerampelinae*.

RUSSULA PERPLEXA Burl. Mycologia **10**: 96. 1918. Apparently the type.

The *spores* are yellowish in NH_3, in mass about C, 9.5–10.5 × 7.7–8.8 μ, ornamentation 0.8–1.0 μ high, type IV, VI, VIII; *cystidia* with banded contents, 52–55 × 9.5–11 μ. *Dermatocystidia* of the pileus 85–126 × 5.5–8.5 μ, acute or rounded and among them are many hyphae transformed into hairs or primordial hyphae. The carpophores suggest macroscopically *R. badia* or *R. xerampelina*. The *stipe* is still pink and slightly brownish.

Conclusion: Same as for *R. pulchra*.

RUSSULA PRAEUMBONATA Burl. Mycologia **13**: 134. 1921. "From type."

The *spores* are 9.8–11.8 × 6.8–9.8 μ, ornamentation 0.9–1.3 μ high, type III, mostly IIIa with very fine, rarely less fine, connecting lines; *basidia* 34–43 × 10–12.3 μ; *cystidia* 44–50 × 7.3–7.5 μ; *cutis* of the pileus consisting of thin-walled septate cylindrical hyphae of 2.5–8.5 μ in diameter, and immediately under these hyphae are the sphaerocysts of the trama.

Conclusion: A well characterized species of the *Lilacea*-group of *Lepidinae*.

RUSSULA SULCATIPES Murrill, Mycologia **4**: 291. *pl. 76, fig. 4.* 1912. Type specimen.

The *spores* are 7.3–10.5 × 6.7–8.5 μ, ornamentation 0.3–0.8 μ high, type II–IIIa, IIIb, some IV, V, VI; *basidia* 34–48 × 10–11 μ; *cystidia* very numerous near the edge, rarer on the sides, without contents, fusoid, but often narrowed in the middle, with a remarkably long (up to 20 μ!) appendiculus, about 70 × 8.5 μ; *hyphae of the cuticle* of the pileus very long and scarcely septate, some of which are hair-like, 4 μ thick: *dermatocystidia* none. The specimens show far more greenish tints than one might assume from reading the original diagnosis and from examination of the

figures. The sulcate stipe is not very evident in the dry condition. The margin is subacute, then subobtuse.

Conclusion: This fungus belongs to the section of *Chlorinae*. I am inclined to think it is merely a form of *Russula Mariae*.

RUSSULA HIBBARDIAE Burl. Mycologia **13**: 132. *pl. 7, fig. 4.* 1921. Specimens from the type locality: Newfane Hill, Vermont.

The *spores* are 6.8–9.5 × 6.3–8.5 μ, ornamentation consisting of faint granulae or spines up to 0.8 μ high, type IIIb, IV, V, some VII–IX; *basidia* 37 × 12 μ; *cystidia* with granular or banded contents, obtuse or acute, often appendiculate (appendiculus 2–10 μ long), those on the edge more often appendiculate or acuminate than those on the sides of the lamellae; *epicutis* of the pileus with hairs and primordial hyphae (2–7 μ in diam.); *dermatocystidia*, none. The margin of the pileus is rather thin, not rounded. Dried specimens with greenish tints.

Conclusion: Like the preceding species, *R. Hibbardiae* seems to be closely related to the *R. Mariae*-group, but it is distinguishable from *R. Mariae* by the spore characters, and also macroscopically.

RUSSULA FLOCCULOSA Burl. N. Am. Flora **9**: 213. 1915. Type.

Spores are 6.8–9 × 5.5–7.3 μ, ornamentation 0.2–0.4 μ high, type IIIb, IV, exceptionally II–IV, most frequently with very fine, interrupted connecting lines; *basidia* 33 × 8.5 μ, 4-spored; *cystidia* versiform, with a faint granular content, 50 × 7–8 μ; *pileus* without dermatocystidia, but with numerous hairs in the epicutis; from a sphaerical, irregularly rounded basal hypha (about 11 × 7–8.5 μ) strongly reduced at the septa, arises a long filament of 2–6 μ diameter, while some other hairs are cylindrical-multiseptate without the sphaerical basal cell.

Conclusion: The general appearance of the dried specimens and all microscopical data except the spore ornamentation suggest *R. vesca*. The substratum, beech leaves, is not in disaccord with this interpretation. A long cylindrical stipe and subdistant lamellae are not typical, but also not impossible for *R. vesca*. The most important difference is in the spores, which are reticulated in

R. vesca "forma tenuis" J. Schaeffer which, however, differs macroscopically. Further studies on the variability of these characters connected with establishing of the $FeSO_4$ reaction may decide whether this plant is a subspecies or form of *R. vesca,* or a closely related but distinct species.

There is another closely related eastern species, *R. brunneola* Burl. N. Am. Flora **9**: 233. 1915. I have not seen the type, but specimens which must have been collected near the type locality in Vermont seem to be not distinct from the European *R. vesca* f. *Romellii* Sing.

R. vesca has hitherto been reported twice in America (Kauffman, 1909, and McIlvaine, 1902), but these indications used to be considered as doubtful. Although I found the typical European *R. vesca* rather frequently in Maine and New Hampshire, some under *Betula* and some under *Fagus*. The reactions and the spore ornamentation are exactly the same as in the European plants. Even the color of the pileus does not differ here, and the white stipes were tapering downwards. There can be no doubt that the true *R. vesca* f. *typica* exists in North America.

RUSSULA GRISEA and RUSSULA CAERULEA sens. Bres.

Specimens of these species, the latter considered as a variety of *R. grisea,* collected and determined by Bresadola, are not distinct from *R. Ferreri* Sing.: *Spores* 7.5–8 × 6–6.5 μ, ornamentation 0.3–0.4 μ high, type IV, also VI (VIII); *cystidia* with content, 8–10 μ broad. Bresadola, Iconographia, pl. 452, is therefore correctly interpreted as *R. Ferreri* in my commentary of Bresadola's *Russula*-pictures (Rev. Myc. **1**: 287. 1936).

RUSSULA DAVISII Burl. Mycologia **10**: 93. 1918. Specimen, collected by the author of the species, preserved at N. Y. Botanical Garden.

Spores 9.5–14.5 × 7–13 μ, yellow in NH_3, ornamentation about 1.6 μ high, type VI; *basidia* 47 × 15 μ; *cheilocystidia* 70 × 9–10 μ, acute.

Conclusion: Probably near to or identical with *R. olivacea* (Schaeff.) Fries.

RUSSULA MURRILLII Burl. Mycologia **5**: 310. 1913. Type.

This plant is identical in all regards with *R. punctata* Krombholz sens. Sing. = *R. Turci* Bres. sens. Maire, Melz. & Zv. = *R. amethystina* Quél.

RUSSULA RUBRIOCHRACEA Murrill, Mycologia **4**: 293. 1912. Type.

The *spores* are 9.3–10.5 × 8.5–9 μ, yellow in NH_3, ornamentation 0.4–2.2 μ high, type VI, sometimes IV, V; *basidia* 23–43 × 10–16.2 μ, usually 35–43 × 11–15 μ; *cystidia* 56–85 × 7.7–11 μ, numerous, with banded content, often with appendiculus (3.5–8 μ long); *dermatocystidia* of the pileus moderately numerous, 6–8 μ thick. Some of the 1.5–3.3 μ thick normal hyphae are transformed into fusoid, acute, empty bodies (hairs) of 6 μ diameter in the epicutis.

Conclusion: If *R. rubriochracea* is not one of the acrid forms of *R. xerampelina*—the specimens look like *R. xerampelina* var. *rubra*—then it is a good species of the *Rubrinae*, well distinguished from *R. Mariae* by the spore ornamentation, from *R. rubra* by the red stipe and from *R. badia* by the less reticulate spores.

RUSSULA MORDAX Burl. Mycologia **28**: 259. 1936. Type.

Spores 7.7–10.2 × 6–8.5 μ, ornamentation about 0.9 μ high, type IIIa, some IIIb; *basidia* about 50 × 10–10.5 μ; *cystidia* 50–60 × 6.6–10 μ, rather numerous, with banded contents, versiform; *dermatocystidia* numerous. The color of the spores in mass must be at least E (stated by comparison).

Conclusion: The macroscopical appearance and the above indicated micro-characters prove that the type of *R. mordax* belongs to *R. badia* Quél. The differences indicated by G. S. Burlingham (l. c.) are not important enough for separating a variety. The consequence is that an actually new species described by me as *R. ? mordax* Burl. vel sp. nov. (Bull. Soc. Myc. Fr. **54** (2): 144. 1938) is not *R. mordax*. I therefore propose for it the new name **R. chrysodacryoides** Sing. nom. nov.

RUSSULA SERISSIMA Peck, Bull. N. Y. State Mus. **139**: 44. 1910. Apparently the type, which was collected by Blackford, and is preserved at the Farlow Herbarium.

Spores 10.5–13.3 × 8.7–10.5 μ, ornamentations 0.8–1.2 μ high, type VI, sometimes IV, V; *basidia* 40 × 12 μ. In the *epicutis* of the pileus are numerous hairs and very scattered dermatocystidia, which are rounded above and show some content; they measure about 75 × 12 μ.

Conclusion: This species does not belong to the *Decolorantinae* nor is it related to *R. serissima* Kauffm. (Herb.) which has reticulate spores. Peck says: "Not changing to brown where wounded," but it is apparent that the type belongs to *R. xerampelina.* Actually *R. xerampelina* (under the name of *R. atropurpurea* Peck) is cited in North American Flora in the same section (*Atropurpureae*) and differs, according to the key, chiefly in the different tinge of the wounds. Hence, the whole section of the *Atropurpureae* disappears, as both species are only forms of *R. xerampelina.*

RUSSULA BARLAE Quél. sens. Mass. Bot. Trans. Yorksh. Nat. Un. **4**: 132. 1905. Specimen, collected by Massee, sent from the Kew Herbarium to N. Y. Botanical Garden.

These specimens do not seem to be *R. xerampelina* var. *Barlae* sens. Sing., Melz. & Zv., J. Schaeffer, although a note, found in the same cover, indicates that the plate of Cooke (apparently *Pl. 1061–1040*) is painted from this same specimen. Thus it will be preferable to omit the name of Massee and Cooke when *R. xerampelina* var. *Barlae* is cited and to write merely: var. *Barlae* Melz. & Zv. This combination is possible because Massee, British Fung. Flora **III**: 62. 1893, related his *Barlae* to his *vesca,* not to *xerampelina;* later he mentions it as a distinct species.

RUSSULA CINERASCENS Beardslee, Jour. Elisha Mitchell Sci. Soc. **33** (4): 164, 1918.

Beardslee's specimens from North Carolina have *spores* of 7.7–9 × 7–7.7 μ with a very low ornamentation (about 0.3 μ) of type IIIa, II–VII; *cystidia* 62–77 × 8–11.5 μ with banded contents all

over or only in a part of the cystidium, very crowded on the edge of the lamellae which is heteromorphous; the *cystidia* are versiform, usually larger at the upper third and often appendiculate (2 μ and more); *dermatocystidia* are present.

Conclusion: This is a good species of the subsection *Decolorantinae* distinguished from *R. decolorans* by the short ornamentation of the spores. See also the next species.

RUSSULA BURKEI Burl. Mycologia **16**: 21. 1924. Type.

Spore print about C–D. *Spores* 8.5–9 × 7.5–8 μ, ornamentations about 0.3 μ, type IIIa; *basidia* 30–40 × 9–12 μ; *cystidia* numerous, 55–66 × 8–10 μ, versiform, often clavate or fusoid, with banded contents; *dermatocystidia* of the epicutis of the pileus clavate, 27–42 × 5–6 μ. The dried specimens showed more reddish tints than indicated in the diagnosis.

Conclusion: The micro-characters of this and the preceding species are almost the same and the only differences are the taste and the odor. Although I found fresh material of the acrid form without any odor comparable to the odor of *Russula foetens,* I am inclined to believe that *R. Burkei* is only the acrid variety of *R. cinerascens,* as *R. variata* is the acrid variety of *R. cyanoxantha.* But Dr. Gertrude S. Burlingham, to whom I addressed myself in this matter, answered me: "I would say that these two are distinct. . . . I find that while the two have similar markings, the spores of *R. cinerascens* are more nearly globular and that the protuberances are smaller and that there are more connecting lines in the spores of *Russula Burkei.*" Description of fresh material of *R. Burkei:*

Pileus with pink reddish spots on cream pale ground (like Britzelmayr's pictures of *Russula Britzelmayri*), often with rusty brownish small spots in the center (like *Russula maculata*), at last fading, convex or campanulate-convex, becoming almost flat and usually depressed in the center, 75 mm. broad; *cuticle* separable about halfway to the center, shining when dried, glabrous, viscid when moist, margin subacute, later obtuse and rounded, even or very shortly striate-undulate; *dermatocystidia* numerous, blue in SV; *lamellae* whitish yellow, later cream-colored and at last the same color as in *Russula decolorans* (perhaps a little paler), equal,

few or none forking but with ground-anastomoses, broadest in the outer third, rather broad (about 10 mm.), rounded-free or narrowed-free, crowded; *spore print* nearly D; *spores* 8.5–9 × 7.5–8 μ, ornamentations 0.2–0.3 μ high, type IIIa, VII; *cystidia* 50 × 7.8–13 μ, usually acute, with banded contents, blue in SV, numerous; *stipe* white, greyish where handled, often rusty brownish at the very base, smooth, slightly ridged, solid or stuffed, firm, up to 80 × 32 mm., tapering upwards; *dermatocystidia* numerous; *flesh* white, reddening, then greyish black where wounded, greyish or blackish in old and in dried specimens, firm, thick; *taste* becomes slowly very acrid. The *odor* is faint, fruity, not recalling *Russula foetens* nor *Russula maculata*. Formaline: quick reddish reaction.

HABITAT: Mixed woods (*Fagus, Pinus, Tsuga, Acer*), Chocorua, N. H., July 26, 1941, coll. D. H. Linder & R. Singer.

RUSSULA MAGNA Beardslee, Jour. Elisha Mitchell Sci. Soc. **33**: 183. 1918.

Beardslee's specimens from Asheville, N. C., preserved at N. Y. Botanical Garden, have now an agreeable particular odor like fresh hard-wood timber. The spores are evidently yellowish (at least C or D). The *lamellae* are broad, moderately crowded, anastomosing, equal; *spores* 9.5–11 × 8–9.5 μ, subglobose, but asymmetrical with a lemon-yellow shine in NH_3, the ornamentations 0.3 μ, very evident and densely reticulate: II–IIIa–VII, but some are also IV–V; *basidia* 42–43 × 9–14 μ, 4-spored; *cystidia* 65–100 × 8.8–10 μ, rather numerous on the sides and exceedingly numerous on the edges of the lamellae, often with banded contents in the middle part, but more often granulate, sometimes septate, versiform, usually more or less fusoid, or occasionally narrowed in the middle part, with an extremely long appendiculus (26–27.2 × 2 μ); *epicutis* of the pileus with broad clavate hyphae 4–4.5 μ in diameter or with cylindrical hyphae that are 4 μ in diameter, hyaline or with a brownish tinge, always with rounded ends; *dermatocystidia* clavate with banded contents, 55–95 × 5.5–6 μ, rather scattered.

Conclusion: An exceptionally well characterized species of the *Decolorantinae* where the plant was placed in my monograph. J. Schaeffer put it into the *Nigricantinae* emphasizing that " this mush-

room belongs in the neighborhood of *R. nigricans* also according to the author." This statement is wrong. Beardslee, the author of the species, writes absolutely correctly: "The dried specimens would probably be taken for *R. nigricans* but it is amply distinct from this species. The yellow spores, nearly equal gills and strong odor, at once distinguish it." And Coker: "It is most nearly related to *xerampelina*" (thus the *Decolorantes*).

RUSSULA CONSOBRINA Fries, Obs. Myc. **2**: 195. 1818 [*Agaricus* (*Russula*)].

As far as I know there is no type of *Russula consobrina* left by Fries. But it is known that a *Russula* as described below is found in "abiegnis" (*Piceetum excelsae*) of Scandinavia and that Karsten who gave a good description of this species and had a large exchange of exsiccata with Fries quoted *R. consobrina* as being found "in silvis abiegnis Fenniae australis passim" (Myc. Fenn. Bidr. Kaenned. Finl. Nat. Folk, Helsingfors, p. 220. 1876). Therefore I searched for some years in the spruce woods of Southern Finland from Helsingfors to the Russian frontier and found that there was only one species comparable to *R. consobrina* which is really not frequent except in the years when *Boletus edulis* is growing abundantly. The following description is the result of my studies on fresh Finnish material and can be considered as covering Karsten's *consobrina* and most probably Fries'. *R. consobrina* var. *rufescens* J. Schaeffer is also identical: *Pileus* umbra, grey brown, paler at the margin, later avellaneous or more rarely greyish pale all over, venose like *Russula vesca*, especially in the center but the veins are "innate" (they do not project but very slightly), otherwise smooth and glabrous, convex and usually umbilicate, later convex with the center depressed, at last infundibuliform, 50–100 mm. broad, exceptionally broader or smaller; *margin* even, only at last not very evidently and not constantly shortly striate-tuberculate, never fibrous, acute to subobtuse, later acute to obtuse, but never rounded. Cuticle separable four-fifths of the radium from the margin towards the center, viscid, quickly drying; *epicutis* consisting of more or less erect non-septate hairs, hyaline above and

brownish colored below, subacute to obtuse, usually with an enlarged base, 1.5–3 μ thick. Between them are found some rather scattered, versiform dermatocystidia which are 33–100 × 6.5–8 μ; *subcutis* with horizontal, normal hyphae of 2.5 μ and more in diameter. Many hairs and hyphae, although morphologically not distinct from the others, are actually lacticiferous bodies and turn blue in SV. The KOH reaction is slow and faint, the tissue becoming only a little darker; *lamellae* cream white, later pale cream, rather broad (8 mm. in large specimens), mostly simple near the stipe, but intermixed with numerous lamellulae or forked lamellae or with both, anastomosing at the base, decidedly not ventricose, narrowed from the middle of the radius of the pileus or from the outer third towards the stipe and narrowed or rounded behind or almost free to free, crowded or rather crowded; *stipe* white, at last usually with a greyish network or with grey spots, often reddening by pressure, rigid, firm, later often becoming fragile, versiform but usually ventricose, solid, later with smooth cavities or stuffed, 65–125 × 20–30 mm., rarely smaller; *dermatocystidia* clavate, 5–6 μ broad; *flesh* white, greyish immediately under the cuticle and greyish also in the old stipes or along the circumference, turning reddish when wounded, but only when the proportion of water is a little under normal (in wet woods there may be no reddening at all), rigid, later more or less fragile, with exceedingly numerous lacticiferae; *taste* slowly to rather quickly becoming very acrid. Odor none, or like that of fresh apples. Formaline: quickly reddening. $FeSO_4$: grey. Aniline: incarnate brownish and brownish-flesh color around the stain, becoming brownish-red at last. α-naphtol: exceptionally slow and slight reaction.

HABITAT: In dense woods of *Picea excelsa,* usually together with *Boletus edulis.* July to the end of September.

Conclusion: This is not the species I described as *R. consobrina* 1926 and 1932. It seems that *R. consobrina* Sing. is a variety of the fungus described by Fries and me under the name of *R. consobrina* var. *sororia.* The true *R. consobrina* as described here belongs rather to the *Decolorantinae* than to the *Foetentinae,* because of the formaline reaction and many other characters.

RUSSULA VINACEA Burl. N. Am. Flora **9**: 217. 1915. "No. 87, same as 85–86" Burl. (85 is the type).

Spores 9.4–10.6 × 8–9.4 μ, the ornamentations rather high and similar to that of *Russula emetica euemetica*, type IIIa; *basidia* 44 × 9.5–12 μ, 4-spored; the *sterigmata* 7 μ long; *cystidia* versiform, 43 × 8.5 μ and more; *dermatocystidia* rather numerous. General appearance of *Russula atropurpurea*.

Conclusion: A good species of the *Atropurpurea*-group, especially near to var. *atropurpurina*, which I first placed as a subspecies next to *R. emetica* because of the long spines of the spores. The type of this European form is lost, so I abandoned this form temporarily. I found the American species near Boston (Purgatory Swamp, Mass.). This enabled me to give a complete description of it:

Pileus "deep purplish vinaceous" (R), "carmin" (R), often in some places fading to "Rose dorée" (R), center usually carmine-blackish or blackish-purple and often rugose, sometimes with small pale or olivaceous spots and finally often brownish or yellowish near the center which is convex and then depressed or finally concave, 55–110 mm. broad, cuticle separable, a third or a half from the margin, not shining when dry, but smooth and viscid when moist; the margin often sublobate, subacute in specimens with close lamellae and obtuse or rounded in the ordinary ones, even or slightly striate-tuberculate when mature; *epicutis* with numerous 4–6 μ thick dermatocystidia (but less than in *R. emetica*). *Hyphae* of the subcutis 1.5–6.5 μ thick; *lamellae* white, often rusty brown where eaten by animals or where broken, close to distant, equal or more often with a few lamellulae, forking or rarely all simple, tapering-free or slightly sinuate-adnexed, strongly anastomosing, moderately broad; *spore print* almost white: more pale than B, but tone of D, between "Cartridge buff" (R) and white; *spores* 8.5–10.5 × 7.7–9.5 μ, ornamentations 1.0–1.3 μ high, type IIIa; *basidia* 26–44 × 9.5–12 μ; *cystidia* versiform, numerous, blue in SV, 43–70 × 7–8.5(–11.7) μ. Aniline: chrome yellow with yellow greenish margin around the stain, later chrome orange with a sea green margin; stipe white, often partially rusty brownish, slightly rugulose firm, later spongy stuffed or staying hard and solid, most often tapering from the base upward, less often nearly equal, 30–70

$\times$ 15–30 mm.; *dermatocystidia* numerous; *flesh* white, sometimes reddish under the cuticle, usually brown where eaten by animals, firm, finally often fragile. The *taste* is very acrid; *odor* none or almost none. $FeSO_4$: greyish pink. Phenol: reddish, soon turning to chocolate brown.

HABITAT: In woods. All my collections were made under *Tsuga*. Kauffman and Burt [5] indicate it under *Pinus*. July (apparently until October).

RUSSULA CRENULATA Burl. Mycologia **5**: 310. 1913. Type.

The *spores* are 11.5 $\times$ 9.5 μ, ornamentations rather high and with very faint reticulations, IIIa, IIIb; *basidia* 33–38 $\times$ 8–12 μ; *cystidia* numerous, versiform, 63–110 $\times$ 8–12 μ, the appendiculus, when present, 2–12 μ long; *dermatocystidia* abundant.

Conclusion: The type of *R. crenulata* being identical with the plant so determined by Kauffman, I can repeat my statement on this latter in a more general way: "*R. crenulata* Burl. is not (as assumed by J. Schaeffer) a form of *R. fragilis* but it is *R. euemetica* f. *alba*" (cf. Bull. Soc. Myc. Fr. **55**: 261. 1939).

RUSSULA REDOLENS Burl. Mycologia **13**: 133. 1921. "No. 15—1917. Paler green than No. 77—1916" (the latter is the type).

The *spores* are 7.7–9 $\times$ 6.5–7.7 μ, ornamentations 0.3–0.9 μ high, type VI; *basidia* 43 $\times$ 8–9.5 μ; *cystidia* 66–68 $\times$ 7.5–15 μ, often bottle shaped, acute or obtuse, often appendiculate, with banded contents.

Conclusion: A very striking species, not comparable with others known to me. It is difficult to put it in the right section unless more complete information about the exact spore color and about the chemical reactions is available.

RUSSULA CAVIPES Melzer & Zvára, Archiv Přirodověd. Vyzkum Čech. **17** (4): 108. 1927. non Britz.

The specimen kindly sent me in 1939 by V. Melzer as a typical one is *R. fallax* (Fries) Sacc. (sens. Singer, J. Schaeffer) in every

[5] Under the name *Russula atropurpurea*. *R. atropurpurea* Kauffm. and Burt-Farlow is *R. vinacea; R. atropurpurea* Peck, Burl. is *R. xerampelina*.

regard. This plant is frequent under fir in Europe, northern Asia, and is met with also in America.

RUSSULA MEXICANA Burl. Mycologia **3**: 26. 1911. Type.

Spores 7.5–9.5 × 6.7–7.7 μ, asymmetrical, ornamentations 0.4–1.1 μ, type IV, V, VI; *basidia* 35 × 18 μ, only on the sides of the lamellae; *cystidia* extremely abundant, 58–120 × 8.5–18.7 μ, fusoid, acute or subacute, with banded content. The edges of the lamellae are sterile, formed exclusively by cystidia. *Epicutis* of the pileus possesses a pigment which becomes intensely pink in NH_3. *Dermatocystidia* versiform, very numerous, often yellowish, sometimes appendiculate, 2–8 μ thick. The stipe possesses abundant dermatocystidia. The base of the stipe is connected with leaves. The *pileus* is bright and intensely cinnabar red. Yellow stains on the younger specimens are very evident.

Conclusion: This is typical *R. lutcotacta* Rea and therefore *R. mexicana* is a synonym of this species.

RUSSULA ROBINSONIAE Burl. N. Am. Flora **9**: 221. 1915. Type.

Spores 9.2–9.5 × 7.2–7.7 μ, ornamentations up to 0.9 μ high, type II–VII (short ridges scarcely anastomosing one with another), but under a high magnification it becomes evident that these thick veins or warts are connected by extremely fine lines which form a broken or complete network (IIIa–IIIb); *basidia* 25–32 × 6.5–11.5 μ; *cystidia* abundant, 58–68 × 5.8–14.5 μ, clavate or fusoid, acute or rounded, with banded content, often appendiculate; *dermatocystidia* very abundant.

Conclusion: This species is macroscopically like *R. Qucletii* or *helodes* but the lamellae are very narrow and close, the cuticle is opaque, the margin thin, acute, even. There are no deep yellow stains. The fungus is associated with *Picea*. *R. Robinsoniae* comes next to the European *R. helodes*, an extremely rare species, met with only in two places every year: one near Tabor in Czechoslovakia, the other near Kazan in Russia. There are, however, some minor differences between the American and European species: (1) Spores and basidia are a little smaller in the American plant and the ornamentation is less regularly reticulate; (2) The

lamellae are anastomosing; (3) The pileus is not lobate as in the European species. Both belong to the *Sardoninae*.

RUSSULA GRACILIS Burl. N. Am. Flora **9**: 222. 1915. "Ex-type."

Spores 8.5–10 × 7.5–8.5 μ, ornamentation 0.4–0.9 μ high, type IV, VI. Hymenium not fit for investigation.

Conclusion: Those macroscopical characters that still remain visible in the specimen and spore characters prove that the American subspecies is very near to the European one: *Spores* of the subsp. *gracillima,* as found in the region of Moscow, U. S. S. R., are 10–11 × 7.5–8.5 μ, when fully mature, but 8.5–11 × 6.5–8.5 μ on the lamellae; ornamentation 0.4–1.0 μ high, type IV, VI. This European subspecies is nearer to the American type than the Altaian subspecies with more connected short spore warts (cf. Bull. Soc. Myc. Fr. **54** (*2*): 143. 1938).

RUSSULA HUMIDICOLA Burl. N. Am. Flora **9**: 230. 1915. Type.

Spores 8–9.8 × 7–8.5 μ, ornamentation not extremely dense, 0.6–0.9 μ high, type IIIb, IV, some spores V, some rare spores VI; *basidia* measure 32–34 × 10.5–13 μ; *cystidia* with banded content, clavate-fusoid, 43–68 × 5–10 μ, rather numerous; *epicutis* of the pileus with long hyphae, many of them apparently lacticiferous because of a loose content, or even cystidia-like and then cylindrical-subfusoid or fusoid, about 70 × 4.5–7.8 μ, others hair-like and blunt-ending, 2–3.5 μ in diameter.

Conclusion: When I found in the Purgatory Swamp, Mass., a species which has the same appearance as the type specimens and the same characters as given in the original description and in the preceding microscopical description, I was able to complete the data about *R. humidicola* sufficiently for deciding its taxonomic position. *R. humidicola* reminds one of the *Puellarinae* because of its habits, dermatocystidia and pale spore print, but its real affinities seem to be in the *Integrinae* group. There is a good plate in the collection of unpublished pictures by Krieger at the Farlow Herbarium. Full description of fresh material:

Pileus "carrot red" to "light carrot red" (R) with the center "morocco red" (R) in young specimens and concolorous in older ones, paler forms "oricut pink" to "orange pink" (R) with the center "carnelian red" (R) and the margin pale or "sea-shell pink" (R) with the center more dirty and the margin white; often slightly umbonate in young plants, later flat or more often convex with a depressed center, at last cup-shaped; 38–70 mm., mostly under 50 mm.; margin soon striate-tuberculate over a large zone, obtuse-rounded; the *cuticle* viscid, later subviscid and drying quickly, two thirds of the radius or entirely separable, not shining when dry. *Epicutis* with rather scattered dermatocystidia which are laticiferae-like in many cases and about 5–6.5 μ thick; *lamellae* white, later cream-colored, broad (4–13 mm.), rather distant to rather crowded, sinuate or rounded-free, anastomosing on the ground, equal, some forking or all simple; *spore print* between C and D; *spores* 8–10.5 $\times$ 7–9 μ, ornamentations 0.6–1.3, mostly 0.9 μ high, type IV, VI, but many of the spores have a very faint network of thin lines: III a–b; *basidia* 20–26 $\times$ 8–10.5 μ; *cystidia* 26–40 $\times$ 6.5–10 μ, clavate, bottle shaped or fusoid, moderately numerous, with scattered or dense coarse granulae, blue in SV in the upper half; *stipe* white, stuffed to hollow, extremely fragile, cylindrical or tapering from the base upward, slightly rugulose, glabrous, 25–70 $\times$ 6–14 mm.; *flesh* white under the cuticle, fragile; *taste* slightly but distinctly acrid when tested with larger quantities of young specimens, and simultaneously slightly bitterish in most cases; *odor,* none. $FeSO_4$: salmon to pale salmon pink. SV: dirty violet.

HABITAT: Under *Quercus* in woods and at the margin of the wood, mostly on the soil, one specimen on decayed wood. July.

Observations: A very closely related species, with almost the same microcharacters but less fragile, shorter and firmer and with pileus more pink-red and pruinose, is very common in June in Van Cortland Park, N. Y.

RUSSULA DISPARILIS Burl. Mycologia **10**: 94. 1918. Type.

Spores 7.7–9.5 $\times$ 6.7–7.7 μ, yellowish in NH_3, ornamentations consisting of cylindrical or conical spines, 0.7–1.0 μ high, type IV,

V, VI; *basidia* 31–47 × 9.5–15 μ; *cystidia* 50–68 × 8.5–9.5 μ fusoid, sometimes in the central or in the upper part, with banded, but often very scattered contents, moderately numerous, a little more numerous at the edge, often, especially at the edge, appendiculate (appendiculus very long 2.5–20 × 2 μ); *epicutis* of the pileus with hyphae-ends about 20 μ long and 4.5–6.5 μ broad; some of them more or less cystidia-like with a few scattered granulae inside; the *pileus* is not shining and glabrous. If one does not know the description, one is inclined to range the specimens near *R. olivascens* Pers.

Conclusion: Further information is needed as to the exact color of the spore print and the SV-reactions. However, it can be said already that I was apparently wrong in relating this species to the *Ingratae*. It does not belong to this group.

RUSSULA FULVESCENS Burl. N. Am. Flora **9**: 229. 1915. Type.

Spores 8.5–12.8 × 7.3–10.2 μ, ornamentation about 0.7 μ high, type VI, some spores V or IV; *cystidia* 58–85 × 10.5 μ, fusoid. Hyphal-ends of the *epicutis* of the pileus hair-like, some resembling primordial hyphae, or narrow cystidia.

Conclusion: Further information is needed as to the exact color of the spore print and the SV-reactions.

RUSSULA MAXIMA Burl. N. Am. Flora **9**: 229. 1915. Type.

Spores 10.8–13.5 × 9–10.8 μ, yellow in NH_3, ornamentation type IIIa; *epicutis* and elements of the hymenium exactly like my recent description of Kauffman's material of this species (cf. Bull. Soc. Myc. Fr. **54**: 148. 1938 and ibid. **55**: 268. 1939).

Conclusion: The type is the same species as that determined as *R. maxima* by me formerly. It is a good species of the *Integrinae*.

RUSSULA RUBROTINCTA (Peck) Burl. N. Am. Flora **9**: 229. 1915.
Coll. Morris in the Adirondacks, det. G. S. Burlingham.

This plant is exactly the European *R. paludosa* in all regards. Miss Burlingham writes in Mycologia **10**: 95–96. 1918: "I have several specimens of *R. elatior* Lindb. which Professor Romell sent

me . . . *Russula elatior* has very much the same appearance as our *Russula rubrotincta*. In fact specimens of this which I sent to Professor Romell he thought must be that species and suggested to me that I be sure that young specimens of that plant, which I had sent him were not acrid. During the following season I tasted these in all stages and found the taste in all cases to be sweet and nutty. . . ." *R. elatior* is a synonym of *R. paludosa* and marks the northern race which I found to be decidedly acrid in the majority of the young specimens, but specimens of the Central-European race are quite mild as a rule and only sometimes big parts of the young hymenium give a slight feeling of acridity. The American plant belongs evidently to this latter form and so does the form collected by me at the type locality in Bavaria. *R. paludosa* is found in America under the same conditions as in Europe: *Sphagnum*-swamps with *Pinus* or *Picea*. Area: New England (Burl., Sing.: Maine; Popham Beach), New York (Peck, Burl., Kauffm.), Canada (coll. D. H. Linder, det. Singer).

RUSSULA INTEGRA var. AURANTIACA J. Schaeffer, Ann. Myc. **31**: 404. 1933. Small samples sent by J. Schaeffer to the Farlow Herbarium and to the Naturhistorisches Museum, Vienna.

Spores 8.3–10.8 × 7–9 μ, ornamentation 0.6–1.0 μ high, type IV, V, VI; *basidia* 42 × 9 μ; *cystidia* numerous, about 50 × 8–10 μ with banded contents; *epicutis* of the pileus with dermatocystidia 40–60 × 4–5 μ. The spore print of the Farlow specimen equals E–F, not H.

Conclusion: I do not think that this is different from *R. Font-Queri* Sing. The spore color " H " indicated by J. Schaeffer may be an exception or simply an error.

RUSSULA BLACKFORDAE Peck, Bull. N. Y. State Mus. **139**: 43. 1910. Type.

Spores 9.5 × 8 μ, ornamentation 0.6–1.3 μ high, type IV, IIIb, IV–VIII with thin and thick connecting lines; *spore print* exactly E; *cystidia* rather numerous, with banded contents; *epicutis* of the pileus with dermatocystidia, 45 × 5.5–7.3 μ, with scattered contents.

Conclusion: It is rather difficult to guess about the position of *R. Blackfordae* before the reactions are known. It seems to be similar to *R. abietina, R. serotina,* and to certain aberrant Asian forms of *R. sphagnophila.* It has nothing to do with *R. puellaris* because of the darker spores.

RUSSULA SPHAGNOPHILA Kauffm. Rep. Mich. Acad. Sci. **11**: 86. 1906. Type.

Spores 8.5–11 × 7.7–9 μ, ornamentation 0.8–1.3 μ high, type mostly IV–V, also VI, IIIb, IV–II, sometimes IIIa, II–IV–VIII, II–IIIb–VIII, the connecting lines very thin, in other spores rather coarse, straight; *basidia* 28–38 × 8.5–10.8 μ; *cystidia* versiform 43–68 × 8.5–11.5 μ, rarely obtuse, more often with a long appendiculus; *dermatocystidia* on the pileus numerous, 25–85 × 2.5–6.8 μ, versiform, mostly rounded at the top; *pileus* 15 mm. broad in dry condition and with the color of the dark purple forms most frequently met with in Europe; *margin* obtuse, striate-tuberculate; *stipe* 32 × 4 mm. in the dried specimen, almost entirely red. Kauffman wrote on the label of this part of the type: "Small specimen"; thus the species is usually larger.[6]

Conclusion: The revision of the type destroys the myth of the allegedly small spores of this species (J. Schaeffer: 7–9 × 7–8 μ, never larger, warts mostly short, ½ μ "in the American" and "most frequently 9–11 × 8–9 μ with ½–1 μ long . . . spines" in the European form. It is interesting that my measurements of the type agree perfectly with J. Schaeffer's measurements of the European form). There can be no doubt any more that the European and the American forms belong to one and the same species. *R. venosa* Velen. 1921 hardly belongs to this species, but *R. betulina* Melzer, non Burl. does. *R. sphagnophila* belongs to the subsection *Puellarinae.*

RUSSULA SUBOLIVASCENS Burl. N. Am. Flora **9**: 223. 1915.

This is not a new species but a nomen novum for *Agaricus olivascens* Secr. *A. Russ. olivascens* Secr. is the same as *Russula olivascens* Pers. and therefore *R. subolivascens* becomes a synonym

[6] Nevertheless I found still smaller fruit bodies in the European form.

of *R. olivascens* Pers. In N. Y. Botanical Garden is a good specimen of *R. olivascens* Pers. (coll. Bres. & Murr. in southern Tyrol), there labeled *R. subolivascens*. I do not know whether or not *R. olivascens* Pers. really exists in this country, but what often is called *R. olivascens* or *subolivascens* in American collections belongs to a group of doubtful forms that I described in 1939 (see Bull. Soc. Myc. Fr. **55**: 266–268. 1939).

RUSSULA TURCI Bres. Fung. Trid. **1**: 22. 1882. Coll. by Bresadola at Mendola and determined by him in August 1900, preserved at the N. Y. Botanical Garden.

Spores 9.5–12 × 7–9.5 μ, ornamentation 1–1.3 μ high, IV, V, VI; *hymenium* largely destroyed but single cystidia with a half or two-thirds-banded contents were observed; *dermatocystidia* of the pileus doubtful as they no longer react with SV.

Conclusion: I am not absolutely sure that this plant belongs to *R. abietina* Peck or to the species called by J. Schaeffer *R. chamaeleontina* or to anything else, but it is evident that it is not *R. punctata*. So far as I know, Bresadola did not mark a type among any of his numerous dried specimens. As it is decidedly not true that all exsiccatae belong to *R. punctata*, it would be more convenient to consider it as a nomen dubium.

RUSSULA BETULINA Burl. N. Am. Flora **9**: 227. 1915. Type.

Spores 9.5–13.5 × 8.5–11 μ, ornamentation 1–2 μ long, mostly 1.5 μ, type VI; *basidia* 39–55 × 10.5–16 μ; *cystidia* 54–90 × 7–10 μ, numerous, acute or obtuse, with banded contents stuffing two-thirds or more of the cystidia; *epicutis* of the pileus with rather numerous dermatocystidia that are 60–85 × 5–9 μ and clavate.

Conclusion: The spores and dermatocystidia distinguish this species as well from *R. integra* (Linné) Fries p. p., sens. Singer (*R. Velenovskyi* Melz. & Zvára) as from *R. betulina* sens. Singer, 1939, which were possibly confused in later collections. I do not know the exact color of the spore print of the type of *R. betulina* but all of the other characters seem to put it near *R. chamaeleon* Sing. and related species of the *Urentinae* (provided the spores being "G" or darker).

RUSSULA ATROVIOLACEA Burl. N. Am. Flora **9**: 220. 1915. Type.

Spores 9–12 × 8.5–9.5 μ, ornamentation 1 μ high, type IIIb, IV–VIII, V, VI; *basidia* 35–47 × 9.5–15.3 μ; *cystidia* rather numerous, 47–77 × 9.5–10.3 μ, cylindrical, fusoid or constricted in the middle, many of them appendiculate (for instance with an appendage that is about 4 μ long); *epicutis* of the pileus with numerous well developed clavate dermatocystidia of 75–115 × 6–9.5 μ. With them in the cuticle are many laticiferae. Normal hyphae 2.5 μ thick, some of them acuminate at the ends.

Conclusion: This species belongs to the *Urentinae*. It is rather near to *R. Cernohorskyi* and *R. nauseosa* var. *atropurpurea*, but seems to be different.

RUSSULA PAXILLOIDES Earle, Bull. N. Y. Bot. Gard. **2**: 341. 1902. Type.

Spores 9–12 × 8.5–10.5 μ, ornamentation 0.9–1.3 μ, type II, III, IV, rarely VI–VIII, II–IV, II–IIIa, II–IIIb, II–VIII; *basidia* 40–65 × 9–14 μ; *sterigmata* 5–10 μ long; *cystidia* 43–64 × 7.7–11 μ, clavate or fusoid, with banded contents, numerous; *dermatocystidia* numerous. The dried specimen has very much the same appearance as *R. maculata*.

Conclusion: As long as the exact spore color of this species is unknown, it cannot be referred to any group. The most striking character of this species is the coarsely cristulate spores.

RUSSULA VETERNOSA Bres. Fungh. Mang. Velen. *pl. 75.* 1899, vix Fries, non Cooke neque al.

Specimen collected and determined by Bresadola in southern Tyrol, preserved at the N. Y. Botanical Garden.

Spores 7.5–13 × 6.5–11 μ, ornamentation 0.8–1.2 μ high, type IV, V, VI, II–IV (*i.e.* with isolated zigzag-lines), VI–VIII, spines mostly isolated and very crowded; *cystidia* about 70 × 8.5 μ, numerous; *dermatocystidia* numerous.

Conclusion: This species is readily distinguished from *R. badia* by its spores and by its colors. As Bresadola's conception does not fit exactly the idea of the Friesian *R. veternosa*, I proposed for it

the name *R. Bresadoliana* (Rev. Myc. 1: 84. 1936). It is quite different from *R. maculata,* and grows under *Pinus* and *Betula* in the mountain zone of the Alps and the Caucasus.

ACKNOWLEDGMENTS

The microscopical analyses of the types and authentic materials treated above were carried out in the Cryptogamic Herbarium of the New York Botanical Garden and at the Farlow Herbarium, Harvard University, Cambridge, Mass. The author is indebted to Dr. Fred J. Seaver and Dr. D. H. Linder, who placed the material at my disposal. Dr. Linder was also kind enough to offer most valuable linguistic advice.

ROOT ROT OF CHAMAECYPARIS CAUSED BY A SPECIES OF PHYTOPHTHORA

C. M. TUCKER AND J. A. MILBRATH

(WITH 14 FIGURES)

INTRODUCTION

A serious root rot disease of *Chamaecyparis* attributed to a species of *Phytophthora* has been reported from the Pacific Northwest (**2**) (**3**). The fungus attacks all sizes of trees, and is especially destructive to established landscape plantings of specimen plants or hedge rows. The disease is known to occur in Oregon and Washington, and since it apparently has been present for sometime before its nature was recognized, the fungus has probably been widely distributed. The disease can readily be mistaken for transplanting injury, and hence it could be present but not recognized.

A description of the disease, the establishment of a new species of *Phytophthora* as the causal organism, and proof of the pathogenicity of this fungus are given in this report.

SYMPTOMS OF THE DISEASE

The foliage symptoms of the disease involve gradual changes in color similar to those which occur when cypress trees die from transplanting injury. The first symptom on blue cypress is a darkening of the foliage by the formation of pigment which produces a purplish cast. As the disease progresses this purple cast and the original blue color gradually disappear until the green undercolor remains and then this variety which is normally blue might be mistaken for one of the green varieties. These first color changes are quite noticeable if the plant is adjacent to a healthy

[1] Published as Technical Paper No. *387* with the approval of the Director of the Oregon Agricultural Experiment Station and as Technical Paper No. *777* with the approval of the Director of the Missouri Agricultural Experiment Station. Contribution from the Botany Department of the University of Missouri and Oregon State College, coöperating.

tree, but if the diseased tree is standing alone it might be mistaken for a healthy tree. Eventually the color fades to a tan and the foliage becomes crisp and dry. When the weather is cool and damp these changes may develop over a period of 2 or 3 months, while the entire sequence occurs in 2 to 3 weeks if the weather is hot and dry. There is never any localization of symptoms; the entire foliage mass follows the same sequence of discoloration. The only foliage symptom on the green varieties is a withering and drying of all foliage, followed by the tan color indicating the death of the plant.

The fungus invades the young roots and spreads into the main trunk killing all tissues as it advances, causing a brown and water-soaked appearance. When the fungus reaches the crown of the plant it spreads out and girdles the trunk of the tree. Then the color changes of the foliage described above begin to develop. The mycelium follows the tissue just outside of the cambium layer, but the brown necrosis extends to the surface of the bark. If the outer portion of the bark is removed a sharp line of demarcation between living and dead cells is apparent a few inches above the crown of the plant. There the necrotic portion which appears a dark water-soaked brown contrasts with the white portion composed of living cells. This advancing edge of fungus invasion reaches the soil line soon after the foliage first becomes discolored. This demarcation between necrotic and living tissue is very characteristic and readily distinguishes the disease from transplanting injury.

The disease affects seedlings, rooted cuttings, small trees, or old established trees with trunks several inches in diameter.

The rate of spread and development of the disease is erratic. Some blocks of nurserystock planted in infested soil have been completely destroyed in 6 months time, while other infested plantings continue to die over a period of 3 or 4 years. The disease may spread out from an infection center, or single trees may die any place in the nursery. The type of soil drainage is an important factor in determining the behavior of the disease in a planting. When infection occurs in old established hedge rows 3 or 4 trees die each year unless there is drainage down the row in which case the spread is more rapid. When dead trees are replaced with healthy trees the latter die in about 6 months time.

THE FUNGUS

Studies on the morphology and physiology of 11 isolates of the *Phytophthora* from *Chamaecyparis* proved them to be indistinguishable, one from another. They differed, in various respects, from the described species of the genus. The marked similarities of all

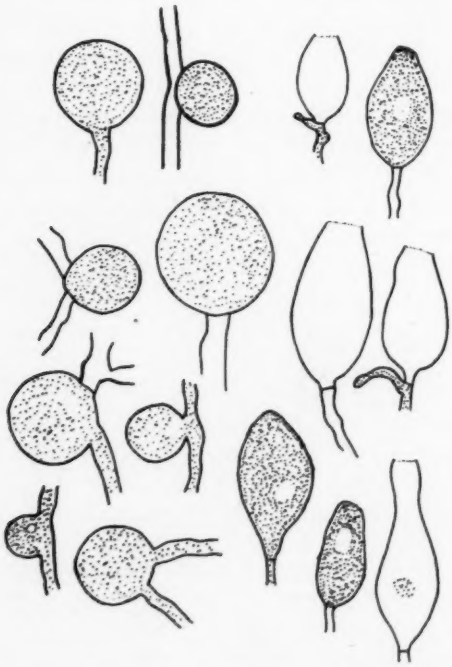


FIG. 1. *Phytophthora lateralis*. Left, terminal and intercalary chlamydospores, showing stages of the characteristic method of development of the latter. Right, sporangia with contents and evacuated.

isolates from *Chamaecyparis* indicate that the group forms a well-defined taxonomic unit. There is no evidence that the organism is merely an aberrant type comparable to those found occasionally among isolates in many species and genera of fungi. The following binomial is proposed for the new species:

Phytophthora lateralis sp. nov.

Hyphis primo continuis, maturitate septatis, vulgo levibus, nonnumquam tuberosis.

Sporangiis in agare cultis nullis, sed copiosis in mattis mycelialibus lavatis e solutione nutritia septem dierum 20° C. ad aquam distillatam et sterilem translatis et septem dies incubatis 20° C.; sympodialiter nascentibus in sporangiophoris non a mycelio distinctis; vulgo ovatis, obovatis, obpyriformibus; nonnumquam elongatis, aut hyalinis aut flavidis, nonpapillatis, cum obturamento apicali et refringenti et pergracili, 26–60 × 12–20 μ, fere circa 36 × 15 μ.

Zoosporis in sporangio formatis, biciliatis, motis concavo-convexis, quietis globosis, in diametrum 10–12 μ.

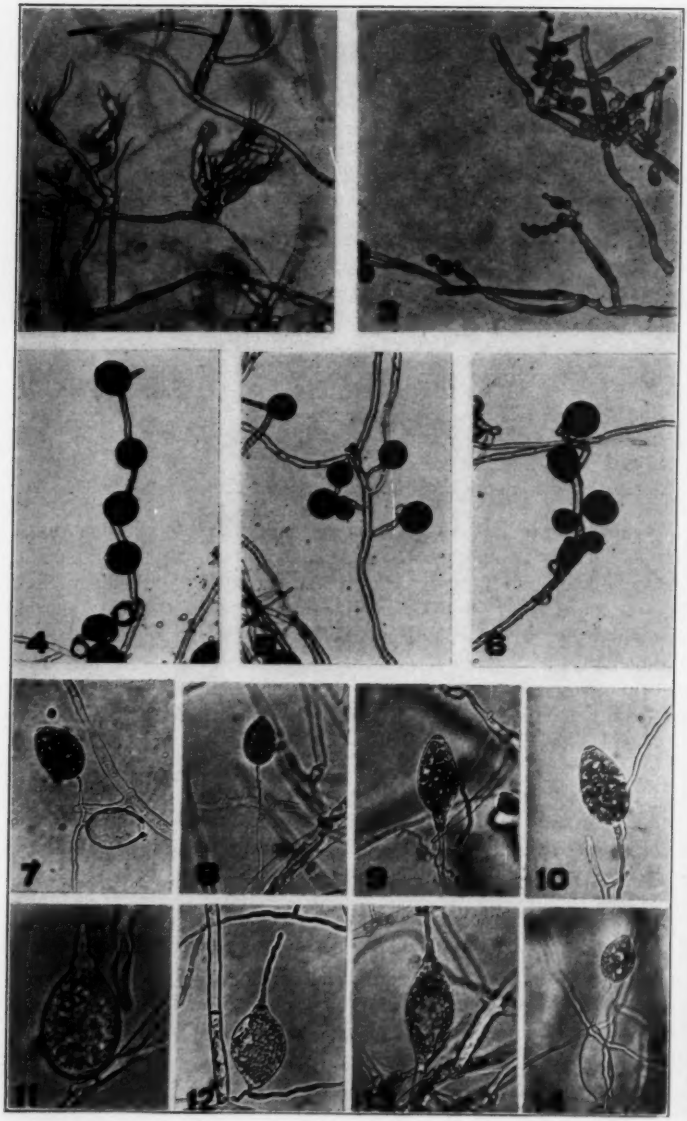
Chlamydosporis copiosis in agare cultis et in liquore, vulgo subglobosis-globosis, nonnumquam ovatis-irregularibus, cum protoplasmate granulis dense repleto, flavidis-subfuscis, cum pariete vulgo tenui nonnumquam crassa (6–7 μ); terminalibus aut *intercalaribus a latere hyphae myceli nascentibus; maturitate saepe evidenter sessilibus;* in diametrum 20–77 μ; fere circa 40 μ; tubo germinantibus.

Oogoniis, antheridiis, oosporis ignotis.

Habitat in cortice vivo *Chamaecyparis Lawsonianae* Parl., Oregon, U. S. A.

Hyphae continuous when young, becoming septate with age, usually smooth, but sometimes gnarled or tuberous. Sporangia none on agar media but developing fairly abundantly on washed mycelial mats transferred from 7-day pea broth cultures (20° C.) to sterile distilled water and incubated 7 days at 20° C.; sporangia borne sympodially on sporangiophores resembling vegetative hyphae, mostly ovate, obovate or obpyriform, occasionally elongate, hyaline to lemon yellow, nonpapillate, with apical refringent plug very thin and often indistinguishable, 26–60 × 12–20 micra, averaging about 36 × 15 micra. Zoöspores fully differentiated within the sporangium, biciliate, reniform in motile stage, spherical in nonmotile phase, 10–12 micra in diameter. Chlamydospores abundant in agar cultures and liquid media, usually subspherical to spherical, occasionally ovate to irregular, contents densely and often coarsely granular, lemon yellow to light brown; wall usually thin, sometimes thick (6–7 micra); terminal or intercalary, *the latter developing as lateral swellings of the hyphae, often appearing sessile at maturity,* 20–77 micra in diameter, averaging about 40 micra; germination by germ tubes. Oögonia, antheridia and oöspores unknown.

Optimum temperature on Difco corn meal agar (pH 6.1) about 20° C. Growth very restricted at 25° C. and inhibited entirely at 30° C.



FIGS. 2–14. *Phytophthora lateralis.*

The type was isolated from *Chamaecyparis Lawsoniana* Parl. in Oregon, U. S. A.

Type cultures have been deposited in the American Type Culture Collection and at the Centraalbureau voor Schimmelcultures.

Phytophthora lateralis exhibits certain similarities to the group of species which includes *P. Cinnamomi, P. erythroseptica, P. cambivora, P. cryptogea, P. Richardiae* and *P. Drechsleri,* particularly in its failure to produce sporangia on agar media and the nonpapillate character of the sporangia (FIG. 1, 7–10). *P. lateralis* produced sporangia only on tufts of mycelium transferred from pea broth cultures, washed and incubated in sterile distilled water, according to the procedures suggested by Rands (**4**) and Leonian (**1**). The sympodial type of development is common, new sporangia developing at the tips of branches of the sporangiophores which arise near the base of an old sporangium (FIG. 1). The resumption of growth of the sporangiophore through the base of the evacuated sporangium, and the production of new sporangia within or beyond the empty one which is frequent in other species with nonpapillate sporangia was also observed in *P. lateralis.* The species differs from others with nonpapillate sporangia in the type of development of intercalary chlamydospores which arise as lateral outgrowths from the hyphae (FIG. 1). The appearance of the chlamydospores differs markedly from that of the clustered, less fully differentiated chlamydospores or " vesicles " produced by the other species of the group. As the chlamydospores of *P. lateralis* mature they often appear to be sessile on the hyphae or supported by 2 hyphae attached to the wall in near juxtaposition (FIG. 1, 4–6).

Phytophthora lateralis grows on the usual agar media, such as potato dextrose agar, corn meal agar and oatmeal agar, but its rate of growth is much slower than in the related species. In this respect the species suggests the slow-growing *P. infestans* and *P. Phaseoli,* from which it is clearly defined by morphologic differences.

Frequent searches for sexual organs were made in liquid cultures and in potato dextrose and oatmeal agar cultures up to 6 months old. Chlamydospores were abundant in the old cultures but oögonia and antheridia were not found.

One of the writers (**5**) has shown that the temperature-growth relations of *Phytophthorae* are fairly constant within species, and

that they may be of some value in differentiating species lacking conspicuous and characteristic morphologic distinguishing characters. The 11 isolates of *Phytophthora lateralis* were grown 2 weeks at 20° C. on Difco corn meal agar (pH 6.1) in Petri plates.

TABLE 1

GROWTH OF ISOLATES OF *Phytophthora lateralis* AT VARIOUS TEMPERATURES ON DIFCO CORN MEAL AGAR (pH 6.1)

Isolate No.	Growth period (days)	Diameter of mycelial growth at				
		10° C. mm.	15° C. mm.	20° C. mm.	25° C. mm.	30° C. mm.
459	4	t *	13	14	0–sl	0
	8	sl	18	25	sl	0
513	4	t	sl	12	sl–14	0
	8	sl	14	25	sl–16	0
535	4	t	sl	16	t	0
	8	sl	18	29	t	0
536	4	0	sl	14	t–14	0
	8	sl	15	28	sl–15	0
567	4	t	sl	15	0–t	0
	8	11	15	25	0–sl	0
568	4	t	sl	16	0–sl	0
	8	13	21	29	0–11	0
572	4	t	sl	13	0–sl	0
	8	11	16	24	t–sl	0
581	4	t	11	17	0–t	0
	10	18	22	32	0–t	0
582	4	t	sl–12	15	0–sl	0
	10	16	19	30	0–sl	0
583	4	t	13	15	sl	0
	10	15	25	28	sl	0
584	4	t–sl	15	17	15	0
	10	18	28	31	23	0

* t—trace, growth barely discernible. sl—slight, growth easily discernible, but too slight for measurement.

The cultures were cut into 5 mm. squares, one of which was transferred to the center of each of 10 Petri plates of the same medium. The plates were incubated, in pairs, at 10° C., 15° C., 20° C., 25° C. and 30° C. The mycelial growths were measured after 4 and 8 or 10 days. The results are given in Table 1.

The isolates behaved very similarly in their responses to various temperatures. No. 584 proved somewhat more resistant to 25° C. than the other 10 isolates. All isolates grew very slowly at 10° C., somewhat more rapidly at 15° C., and made their best growth at 20° C. A temperature of 25° C. is apparently very near the maximum, resulting in reduced growth of all isolates. At 30° C. there was no growth and, after 8 days exposure, the fungus in the inocula was dead.

The low temperature requirement for growth of *Phytophthora lateralis* is similar to that of *P. hibernalis, P. infestans* and *P. Syringae,* where growth is inhibited at 25° C. (**5**). However, these 3 species all possess distinguishing morphologic features quite different from those of *P. lateralis.*

The type of mycelial growth on Difco corn meal agar at 20° C. has no distinguishing characters. Growth is regularly circular, submerged, frequently slightly rhizoidal in appearance.

Apple (Delicious) fruits and potato (Idaho Russet) tubers were inoculated with each of the 11 isolates by inserting a tuft of mycelium into a short slit 7 mm. in depth. The wounds were covered with white petrolatum to prevent drying, and the fruits and tubers were incubated at 20° C. After 20 days the apple fruits showed a dark brown, firm, usually sharply delimited area of invaded tissue ½ to 1 inch in diameter at most of the wounds. The Phytophthora was reisolated. The potato tubers remained entirely free from evidence of infection.

The fungus may be identified readily by the nonpapillate sporangia and the large intercalary chlamydospores which arise as lateral swellings on the hyphae, resulting in a characteristic sessile or double-stalked appearance. The slow growth and low temperature requirement are valuable confirmatory characters.

PATHOGENICITY

Phytophthora lateralis is readily isolated by taking pieces of tissue near the cambium area showing the advancing edge of the necrosis, and placing these on potato dextrose agar. If isolations are made from the crown of the trees when the foliage first becomes discolored it is not uncommon to obtain pure cultures of the *Phy-*

tophthora from every piece of such tissue. *Fusarium* and other fast growing secondary organisms follow closely behind the *Phytophthora*, and these fungi are the only ones recovered from dead roots or tissue that has been necrotic for some time.

Phytophthora lateralis has been isolated from 23 different collections of *Chamaecyparis Lawsoniana* Parl. var. *alumi* Beiss., 1 collection of *C. Lawsoniana* Parl. var. *erecta* Sudw., and 1 collection of *C. obtusa* Sieb. & Zucc. var. *gracilis* Nash. The collections consisted of 1 to 10 trees from different localities and yearly collections from the same locations. *C. Lawsoniana* Parl. var. *alumi* Beiss. is the predominating variety used for ornamental purposes and is therefore the frequent host for the fungus.

TABLE 2

INOCULATIONS WITH *Phytophthora lateralis*

Method of inoculation	No. of inoculations	No. of plants inoculated	No. of plants positive
Agar cultures	9	33	30
Pea broth cultures	7	40	35
Soil	2	12	12
Checks	7	21	0

The pathogenicity of *P. lateralis* is readily demonstrated. Three methods of inoculation have been used and all appear equally effective, as shown in Table 2. When the fungus was growing on potato dextrose agar media bits of the mycelium were placed under the bark through wounds on the crown or on the roots. Checks were similarly treated with sterile media. Cultures of the fungus in pea broth were introduced into the soil about the roots of the plant. Soil inoculations were made by taking the soil and roots from around diseased plants and mixing them with the soil in which the cypress were to be grown.

Small, well rooted plants of *Chamaecyparis Lawsoniana* var. *alumi* have been used in all of these pathogenicity studies. Further pathogenicity studies connected with another phase of this problem indicate that all varieties of *C. Lawsoniana* are susceptible, some of the varieties of *C. obtusa* are susceptible while others are resistant, and that all varieties of *C. pisifera* show resistance. None of the other conifers are known to be susceptible.

SUMMARY

A root rot of *Chamaecyparis* occurring in Oregon and Washington is attributed to *Phytophthora lateralis*.

The fungus invades the young roots and eventually girdles the trunk; characteristic color changes of the foliage accompany the destruction of root and stem tissues and infected trees are killed.

In culture the causal fungus grows slowly on agar media. The optimum temperature is about 20° C.; growth is reduced at 25° C., and inhibited at 30° C.

The disease has been identified in *Chamaecyparis Lawsoniana* var. *alumi*, *C. Lawsoniana* var. *erecta* and *C. obtusa* var. *gracilis*.

UNIVERSITY OF MISSOURI,
COLUMBIA, MISSOURI,
AND
OREGON STATE COLLEGE,
CORVALLIS, OREGON

LITERATURE CITED

1. **Leonian, L. H.** Identification of *Phytophthora* species. W. Va. Agr. Expt. Sta. Bull. *262*, 36 pp., *illus.* 1934.
2. **Milbrath, J. A. & F. P. McWhorter.** Preliminary recommendations for the control of the root and crown disease of cypress. Ore. Agr. Expt. Sta., Cir. of Information 187. 2 pp. 1938.
3. **Milbrath, J. A.** A *Phytophthora* disease of *Chamaecyparis*. Phytopath. **30**: 788. 1940.
4. **Rands, R. D.** Streepkanker van kaneel, veroorzaakt door *Phytophthora Cinnamomi* n. sp. Dept. Landb. Nijv. en Handel (Dutch East Indies) Meded. Inst. Plantenziekten Afd. 54, 53 pp., *illus.* 1922.
5. **Tucker, C. M.** Taxonomy of the genus *Phytophthora* deBary. Mo. Agr. Expt. Sta. Res. Bull. 153, 208 pp., *illus.* 1931.

EXPLANATION OF FIGURES

All figures are of *Phytophthora lateralis*.

FIG. 1. Drawings by C. M. Tucker. Left, terminal and intercalary chlamydospores, showing stages of the characteristic method of development of the latter. Right, sporangia with contents and evacuated.

FIG. 2–14. Photomicrographs of unstained water mounts of living material by F. P. McWhorter and J. A. Milbrath. (2) Young mycelium (× 100) recently isolated to show large tortulous type of branching; (3) mycelium (× 100) from older culture showing gnarled branching; (4–6) characteristic development of chlamydospores (× 100); (7–14) characteristic development of sporangia (× 200); (7) evacuated sporangium and sporangium with contents; (8–10) characteristic types of sporangia; (11–13) germination of sporangia to produce new mycelium; (14) an evacuated sporangium followed by the development of a second sporangium.

A NEW FUNGOUS PARASITE ON DUNG-INHABITING ASCOMYCETES

MARION L. LOHMAN[1]

(WITH 15 FIGURES)

In December 1940 during the routine study of *Ascobolus stercorarius* in a laboratory class in cryptogamic botany, a student, Mr. Joseph Lipps, had the good fortune to discover an ascus-borne chytridiaceous sporangium emitting its zoöspores. With subsequent inspections of some of the various kinds of ascocarps and spores to be found on cow dung, I have seen many additional sporangia upon asci and ascospores of *A. immersus, A. Leveillei,* and *A. stercorarius,* and in a very few instances upon cells of the exciple in fructifications of the last named species.

Inasmuch as the current taxonomic treatments of the Chytridiales include no records of non-filamentous Phycomycetes upon any species of the Ascomycetes, I extended the observations on this parasite to include a survey of apothecia that developed in moist-chamber cultures of dung from several pastures, incorporating studies on the capacity of the organism to infect various Ascomycetous fungi as determined by rather crude but useful inoculation tests in hanging drop cultures.

While chytridiaceous fungi are of common occurrence on non-filamentous and Oömycetous Phycomycetes, they apparently are rarely associated with higher filamentous fungi. With special reference to the Rhizidiaceous forms in the latter association, one finds in the literature but two species, namely, *Olpidium Uredinis* (Lagerh.) A. Fischer, on uredospores of *Puccinia,* and the tropical *Rhizophidium fungicolum* Zimm. in association with hyphae of

[1] In the study of this fungus I am indebted to Mr. J. D. Lipps and Mr. F. S. Shuttleworth for certain field collections; to Dr. G. W. Prescott for the tentative specific determinations of the Algae mentioned; and to Prof. John N. Couch for helpful communications concerning his observations on the habit of the fungus in culture. The names of Discomycetous fungi mentioned herein are after Seaver (5).

Gloeosporium Theobromae. Zimmermann (**7**) observed that the zoöspores of the *Rhizophidium* infected only the hyphae of the *Gloeosporium*, while hyphae of other fungi, probably Ascomycetes, were intermingled.

Although the present fungus on *Ascobolus* and other Ascomycetes conforms to the genus *Rhizophidium* in consideration of the shape of its sporangia, number of exit papillae, and size and shape of zoöspores, because of the presence of a distinct and moderately large subsporangial vesicle in certain sporangia it is herewith tentatively referred to *Phlyctochytrium* with the following diagnosis:

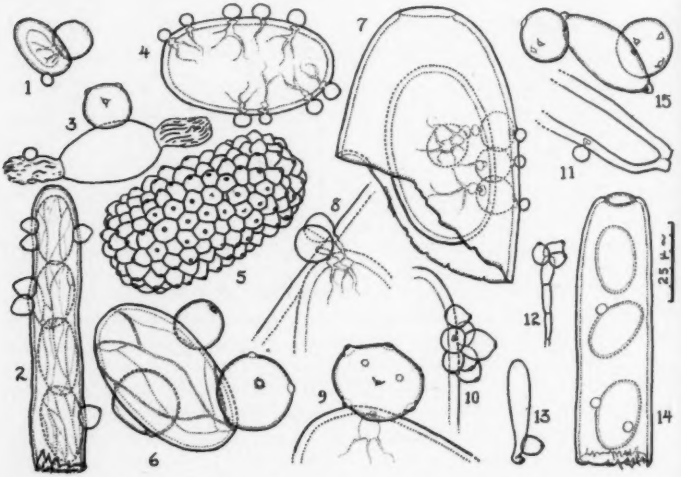
Phlyctochytrium Lippsii, sp. nov. (FIGS. 1–15)

Fungus perniciosus in sporidiis fungorum ascophororum fimicolum, hic quidem visum est—Zoosporangiis ex parte intramatricali orientibus, subglobosis aut pyriformibus, sessilibus vel rarissime brevi-stipitatis, levibus, subhyalinis, tenuiter tunicatis, 7–36 μ diam., papillis 1–3–10-ornatis; zoosporis motis formantibus in sporangibus minoribus sex octo, majoribus circa sexaginta, subgloboso-ellipsoideis, hyalinis, 3–4 μ diam., per orificia inornata singulatim liberatis; cilio circa 25 μ longo; cellula intramatricali 2–10 μ diam., plerumque ignota; rhizinis angustis ramosis radiantibus crassis bifurcisve praedita.

Obs.: Fungus in natura et culturis in specibus *Ascoboli, Ascophani, Lasioboli* et *Sordariae* prope Bloomington, Indiana, U. S. A.

Zoösporangia external to nutritive host cell, single or aggregated, occasionally short-stalked but typically sessile, obovate when densely clustered, to globose or globose-flattened when free, 7 to 36 μ in diameter, with smooth, hyaline to pale yellowish wall which at maturity in the larger individuals is approximately 1 μ in thickness, appearing double, with 1 to 3, occasionally as many as 10, smooth, obtusely rounded exit papillae; zoöspores as few as 6 or 8 in small sporangia, as many as 60 or more in the largest; at first narrow elliptic, 3.5 μ long but after swimming a few minutes elliptic-ovoid, 3 to 4 μ in diameter, with one or two oil drops and posterior flagellum about 25 μ long—at 15 to 20° C. swimming before emission, then escaping freely without vesicle formation and swimming away in a zigzag course; subsporangial vesicle thin-walled, variable in size and shape, 2 to 4 μ in diameter and bead-like, or occasionally 8 to 10 μ in diameter and broadly fusoid—sometimes not evident; rhizoids dendroid and delicate but sometimes from the bead-like apophysis stoutish bifurcate, with delicate terminal branching; resting spores not observed; sporangia viable after normal desiccation for 6 weeks at room temperature.

Observed on *Ascobolus immersus, A. Leveillei, A. stercorarius, Ascophanus Holmskjoldii, Lasiobolus equinus,* and *Sordaria coronifera* Grove; typically upon free or undischarged ascospores of Ascobolus species in the vicinity of Bloomington, Monroe County, Indiana.



FIGS. 1–15. Sporangial development in *Phlyctochytrium Lippsii:* 1, 2, on *Ascobolus stercorarius;* 3, on *Sordaria coronifera* (appendages of ascospore swollen); 4–10, on *Ascobolus immersus* ascospores with infection through the ascus wall in figures 7 and 8, the sporangia developed directly upon the ascospore in the former and external to the ascus in the latter (figure 6 illustrates the more typical sporangial condition when infections are few and also shows the markings for the entire surface of a typical, brownish violaceous ascospore; figure 7 illustrates four sporangia on the uppermost of four infected ascospores of a single ascus); 11–14, on hair cell, paraphysis, young ascus, and undischarged ascospores of *Lasiobolus equinus* (see explanations in text); 15, mature, functional sporangia on ascospore of *Ascophanus Holmskjoldii.*

OBSERVATIONS ON FUNGI INFECTED IN THE FIELD

Fructifications and free ascospores of various fungi found upon cow dung were examined from samples taken in five pastures in the vicinity of Bloomington. The first was gathered December 4, 1940; the last April 4, 1941. In the laboratory the samples were

kept in moist chambers and sterile brook water was added to maintain the necessary moisture and to provide at one or more intervals a free water film upon the surface of the ascocarps. Although species of *Ascobolus* were of first interest, ascocarps of *Ascophanus* and *Lasiobolus* and algal cells were examined with equal care. Apothecia were dissected for inspection and previously discharged ascospores were obtained by scraping the surface of the substratum.

The parasite was found on one or more species of *Ascobolus* in samples from three pastures of the following location: Upper watershed of Griffy Creek Reservoir (collections of December 4 and February 15); Dolan watershed of Bean Blossom Creek, 8 miles distant from the former (March 12); Lower watershed of Griffy Creek, one mile from the first pasture (April 4). In each of these collections of samples *A. immersus* was present and infected. Samples taken April 4 in two additional distant pastures yielded only uninfected *A. stercorarius* and a third collection of samples (March 14) from the first location yielded only uninfected *Ascophanus carneus* and *Lasiobolus equinus*.

Altogether, the study of field samples for naturally infected species suggests that the parasite occurs most frequently on *Ascobolus immersus*.

The collection of April 4 in the lower watershed of Griffy Creek afforded the best opportunity to determine the probable relationship of the parasite with certain algae which had been seen sparingly in a number of the samples, resting upon basal portions of dissected apothecia and filling broken vessels of woody fragments in the dung. In this collection ascocarps of *Ascobolus immersus* could not be found but many free ascospores were present in the heavy algal films over the substratum and in beetle excrement both in cavities and upon the surface of the dung. The chytrid sporangia occurred on many of these spores. They could not be found, however, on asci and ascospores, or other cells of *Ascophanus carneus* which was fruiting sparingly, or upon cells of *Chlamydomonas fungicola*, which was very abundant, although mostly encysted, or upon *Hormidium fragilis* which was moderately abundant in both the vegetative and zoösporic phases.

On the assumption that only one chytridiaceous fungus was responsible for the infections observed, algal cells, slide-trapped ascospores, and apothecial fragments with asci were tested for infection in hanging drops of sterile brook water, using infected ascospores or suspensions of zoöspores as inoculum. In these tests the parasite developed upon additional species of fungi.

SPECIES INFECTED IN INOCULATION TESTS

Inoculation tests were observed in hanging drops in "Van Tiegham" cells using for the most part ascospores trapped on sterile slides placed above fragments of dung.[2] Cultures established with hymenial fragments afforded some observations on zoöspore infection through the ascus wall but these were less satisfactory because of protozoan disturbances by the third day. Even though cultures were not purified, it is believed that the results of these tests indicate in some degree the ability of the parasite to infect ascospores of various genera of Ascomycetes.

It was observed that ascospores of *Ascobolus immersus* and *A. stercorarius* regularly developed sporangia, in many instances apparently to the point of complete utilization of the protoplasts. Two sporangia, one inactive, were seen on a single ascospore among several hundred in the case of *Sordaria coronifera* (FIG. 3) and one to three mature sporangia on each of six spores among several hundred in the case of *Ascophanus Holmskjoldii* (FIG. 15). With the latter species, however, three asci containing mature ascospores were found with typical sporangia 10 to 12 μ in diameter—one ascus with five sporangia, one with two, and one with a single sporangium opposite the lowermost ascospore.

Infections found on *Lasiobolus equinus* were less conclusive (FIGS. 11–14). While no sporangia were observed on hundreds of ascospores examined, small empty sporangia were seen on

[2] Reference here is to a modified Van Tiegham cell, inasmuch as garden hose gaskets, washed in alcohol and then soaked in sterile water, were substituted for the usual glass cylinders. With the culture cells stacked in large moist chambers, drop cultures were maintained by this mechanism without difficulty, the films of water between surfaces of glass and rubber preventing rapid evaporation. In practice, after a lengthy microscopic examination, the dry gasket is simply replaced by a moist one, or water added at the edge.

rounded basal and hair cells of the exciple, at the base of an immature ascus, and on tips of several paraphyses, with respect to one of which zoöspores were observed being discharged from three terminal sporangia. They were of the characteristic shape and habit but smaller, measuring $3 \times 2.5\ \mu$. Zoöspores were observed swimming within one ascus which had discharged four of its spores, entrance to which, presumably, they had gained by way of the ascostome. Twelve hours later they were seen encysted on two of the ascospores. After three days, when the preparation was abandoned, they had not enlarged beyond the encystment stage (FIG. 14).

Ascospores and asci of *Ascophanus carneus* remained uninfected. This species was abundant on dung collected in different pastures on March 14 and April 4, and careful inspection of many dissected apothecia revealed no infections. In the first of these collections *Ascobolus* species could not be found but in the second infected free ascospores of *A. immersus* were abundant on the surface in areas containing apothecia of the *Ascophanus*.

The spore suspension drops regularly contained many ascospores of *Sordaria fimicola* (Rob.) Ces. & De Not. and a few of the groups of spores of *Ryparobius sexdecimsporus* and *Sporormia megalospora* Auersw. These spores remained uninfected.

Four preparations of *Chlamydomonas* and *Hormidium* mixed were inoculated with infected ascospores of *Ascobolus immersus*. These were studied until discarded on the eighth day and infected algal cells were not found. The ascospores, however, during this time showed increasing numbers of sporangia, some with more than a hundred, mutually compressed (FIG. 5), others with as many as two dozen large sporangia, the ascospores then existing as collapsed cases.

DISCUSSION AND SUMMARY

That the relative size and position of the subsporangial vesicle in this fungus varies with the nature and continuity of the substratum which the infection strand encounters is evidenced by infections first through the ascus wall and then in turn through the double wall of the ascospore (FIGS. 6–9). While the presence

of the vesicle is retained as a feature for the separation of *Phlyctochytrium* and *Rhizophidium* in systematic treatments (**2**, **4**), Fitzpatrick (**2**), Couch (**1**), Sparrow (**6**), and Karling (**3**), in recognition of possible variability in this particular feature of chytrid morphology, question its usefulness either in delimiting genera or in the generic disposition of certain species. The ranges of variability of about 30 μ in diameter of the sporangia and from 1 to 8 or 10 exit papillae are not extreme in comparison with certain species of *Rhizophidium*.

Observations on the occurrence of this species suggest that it is primarily a parasite of ascospores of species of *Ascobolus* and of *A. immersus* in particular. Ascospores of the latter, either because of some singular feature of the wall or some chemical stimulus together with an abundant food source, attract the zoöspores and become infected to a greater degree than do spores of other species of *Ascobolus* or of other dung-inhabiting Ascomycetes. Perhaps in the absence of ascospores of *A. immersus* those of other species would show a higher incidence of infection when supplied with zoöspores.

Destruction of the endoplast in ascospores of *Ascobolus immersus* is evidenced by collapsed ascospore cases and in rare instances by the inward discharge of zoöspores whereupon the body of the ascospore becomes a swarming mass of zoöspores with no indication of any internal sporangia or any endoplasmic materials impeding them in their rapid swimming.

Chlamydomonas fungicola and *Hormidium fragilis* were found in abundance on substrata in which this fungus occurred on *Ascobolus immersus*. These species were not found to be infected and all attempts to establish infections upon them artificially were unsuccessful.

DEPARTMENT OF BOTANY AND BACTERIOLOGY,
INDIANA UNIVERSITY

LITERATURE CITED

1. **Couch, J. N.** *Rhizophidium, Phlyctochytrium* and *Phlyctidium* in the United States. Jour. Elisha Mitchell Sci. Soc. **47**: 245–260. 1932.
2. **Fitzpatrick, H. M.** The lower fungi. Phycomycetes. 331 pages. New York. 1930.

3. **Karling, J. S.** A new chytrid genus: *Nephrochytrium.* Am. Jour. Bot. **25**: 211–215. 1938.
4. **Minden, M. von.** Chytridiineae *and* Ancylistineae. *In* Krypt.-Fl. Mark Brandenburg **5**: 209–461. 1911.
5. **Seaver, F. J.** The North American cup-fungi. 284 pages. New York. 1928.
6. **Sparrow, F. K.** Observations on the aquatic fungi of Cold Spring Harbor. Mycologia **24**: 268–303. 1932.
7. **Zimmermann, A.** Ueber einige an tropischen Kulturpflanzen beobachtete Pilze. II. Centrbl. Bakt. Parasitenk. II. **8**: 148–152. 1902.

NOTES AND BRIEF ARTICLES

Mushroom Poisoning Caused by Lactaria glaucescens

On July 28, 1941, a telephone message was received from the Children's Hospital of Washington, D. C., in regard to a probable case of mushroom poisoning which had resulted in the death of a two and a half year old child. Mushrooms from the same collection had also been eaten by the mother of the child, who although having been made very ill eventually recovered.

The mushrooms were collected in nearby Maryland Friday morning, July twenty-fifth and eaten at about one o'clock of the same day. Only five mushrooms were cooked and the child ate only a small piece of one about an inch square. The mother ate three of the specimens and pronounced them very good. Nausea and intestinal disturbances followed in a short time and when the husband returned from work in the late afternoon he found the mother and child very ill. In the evening he took them to a physician who gave them some medicine but did not use a stomach pump. The child was ill but walked around the room a little before going to bed, ate a cookie, and asked for water. According to the mother's statement he became worse during the night and by morning was semiconscious. His condition was so alarming that the father again took him to a physician in Rockville, Md., who, recognizing the seriousness of the case, advised the father to take him to the Children's Hospital in Washington. In spite of the excellent care given the child at this Institution he died Tuesday morning, July 29th, 1941, at 12.10 A.M. The mother was not attended at a hospital, and was very ill for a week or so, suffering extreme nausea and severe abdominal pains. As far as could be learned no marked mental disturbances, as intoxication or hallucinations, were produced although extreme nervousness continued throughout the illness.

The possibility of a mixed collection of mushrooms was carefully considered, but doubt as to the species responsible for the trouble

was eliminated. The death of the child and recovery of the mother may be explained by the fact that the child was born with a bad heart and was always delicate.

The specimens submitted for examination and said to be part of those eaten were determined as *Lactaria glaucescens* Crossland. Spores recovered from washings of the child's stomach, after all solid material had been eliminated were identical with the spores of the specimens submitted for examination.

Certain authorities have considered *Lactaria piperata* (L.) Pers. and *L. glaucescens* Crossland identical, but the following characters as exhibited by *L. glaucescens* would seem to establish it as a distinct species: the extremely fine crowded gills, the greenish color of the milk, the small spores and different spore markings.[1]

This is the first case of poisoning caused by eating *L. glaucescens* which has come to our attention. The danger presented by this species is increased by its general resemblance to *Lactaria piperata* which is ordinarily considered edible. Its peppery taste might act as a deterrent in its use as food, but as most descriptions of *L. piperata* mention this as a transitory character which disappears in cooking it would be of little value. To the mycophagist or amateur collector who lacks a microscope, the two striking characters for identification would be the narrow, crowded gills and the greenish color of the milk. This plant is rendered even more dangerous because of its wide geographical distribution and its appearance from early spring until late fall.—VERA K. CHARLES

A CLASSIFICATION OF AQUATIC PHYCOMYCETES

The following outline of a classification of the Aquatic Phycomycetes is one which has been gradually evolved during the course of some years of study of these fungi. Like all such objects it is undoubtedly an imperfect structure and represents nothing more than one person's ideas of the natural affinities of the diverse aquatic organisms now placed in the Phycomycetes.

[1] Grateful acknowledgment is made to Dr. G. S. Burlingham who examined the spores and verified the determination of the species.

As may be readily seen, a primary distinction is drawn on the basis of the structure of the zoöspore, although there are other, correlated characters. Parallelisms in body plan are evident among members of the uni- and biflagellate series. The first three orders are believed to be closely related. The Saprolegniales and Leptomitales also represent related orders. The natural affinities of the others, however, are indeed obscure. The Chytridiales are considered to be composed of two parallel groups which, while differing from one another in their method of zoöspore discharge (inoperculate or operculate), are often of similar body plan. Whether or not the Lagenidiales (the former Ancylistales) has been made too inclusive must await the test of time.

No originality is claimed for some features of the classification.[1] It can be said, however, that it has been arrived at independently and only after a study of a great many of the organisms concerned.

UNIFLAGELLATE SERIES

Order I. CHYTRIDIALES

INOPERCULATAE

Fam. 1. Olpidiaceae
- *Nucleophaga*
- *Sphaerita*
- *Olpidium*
- *Pleotrachelus*
- *Plasmophagus*
- *Rozella*
- *Olpidiomorpha*
- *Pringsheimiella*
- (*? Myrophagus*)

Fam. 2. Achlyogetonaceae
- *Achlyogeton*
- *Septolpidium*
- *Bicricium*

Fam. 3. Synchytriaceae
- *Micromyces*
- *Micromycopsis*
- (*Synchytrium*)

Fam. 4. Phlyctidiaceae
- Sub. fam. Phlyctidioideae
  - *Phlyctidium*
  - *Achlyella*
  - *Rhizophydium*
  - *Dangeardia*
  - *Phlyctochytrium*
  - *Blyttiomyces*
  - *Rhizidiopsis*
  - *Physorhizophidium*
  - *Podochytrium*
  - *Saccomyces*
  - *Scherffeliomyces*
  - *Coralliochytrium*
- Sub. fam. Entophlyctoideae
  - *Entophlyctis*
  - *Diplophlyctis*
  - *Mitochytridium*
  - *Rhizosiphon*
  - *Aphanistis*

Fam. 5. Rhizidiaceae
- Sub. fam. Rhizidioideae
  - *Sporophlyctidium*
  - *Rhizidium*

[1] For the most part, only well established genera are listed.

Rhizophlyctis
Nowakowskia
Sub. fam. Obelidioideae
Obelidium
Rhizoclosmatium
Asterophlyctis
Siphonaria
Sub. fam. Polyphagoideae
Polyphagus
Sporophlyctis
Endocoenobium
Fam. 6. Cladochytriaceae
Catenaria
Cladochytrium
Amoebochytrium
Physocladia
Coenomyces
(Fam. 7. Physodermataceae)
(*Physoderma*)
(*Urophlyctis*)

Order II. BLASTOCLADIALES

Fam. 1. Blastocladiaceae
Clavochytridium (?)
Sphaerocladia
Blastocladiella
Allomyces
Blastocladia

OPERCULATAE

Fam. 8. Chytridiaceae
Sub. fam. Chytridioideae
Chytridium
Catenochytridium
Sub. fam. Zygorhizidioideae
Zygorhizidium
Sub. fam. Macrochytrioideae
Macrochytrium
Sub. fam. Endochytrioideae
Endochytrium
Nephrochytrium
Fam. 9. Nowakowskiellaceae
Sub. fam. Nowakowskielloideae
Nowakowskiella
Septochytrium
Sub. fam. Megachytrioideae
Megachytrium
Tetrachytrium
Zygochytrium

Order III. MONOBLEPHARIDALES

Fam. 1. Monoblepharidaceae
Monoblepharis
Monoblepharella
Gonapodya
(*Myrioblepharis* ?)

[APPENDIX TO UNIFLAGELLATE SERIES]

Fam. 1. Hyphochytriaceae
Latrostium
Rhizidiomyces
Hyphochytrium

BIFLAGELLATE SERIES [2]

Order IV. PLASMODIOPHORALES

Fam. 1. Plasmodiophoraceae
Woronina
Octomyxa
Plasmodiophora
Ligniera
Tetramyxa
Sorodiscus

Order V. SAPROLEGNIALES

Fam. 1. Ectrogellaceae
Ectrogella
Eurychasma
Eurychasmidium
Aphanomycopsis
Fam. 2. Thraustochytriaceae
Thraustochytrium

[2] Professor J. N. Couch has suggested that this series be divided into two, one with flagella of very unequal length (Plasmodiophorales), the other with equal or nearly equal flagella.

Fam. 3. Saprolegniaceae
Pythiopsis
Aplanes
Saprolegnia
Isoachlya
Leptolegnia
Achlya
Protoachlya
Sommerstorffia
Aphanomyces
Plectospira
Calyptralegnia
Thraustotheca
Dictyuchus
Brevilegnia
Geolegnia

Order VI. LEPTOMITALES

Fam. 1. Leptomitaceae
Leptomitus
Apodachlya
Apodachlyella
Fam. 2. Rhipidiaceae
Sapromyces
Rhipidium
Araiospora
Mindeniella

Order VII. LAGENIDIALES

Fam. 1. Olpidiopsidaceae
Pseudolpidium
Olpidiopsis
Petersenia
Pythiella
Pseudosphaerita
Fam. 2. Sirolpidiaceae
Sirolpidium
Pontisma
Fam. 3. Lagenidiaceae
Myzocytium
Lagenidium
Resticularia
(*Lagena*)

Order VIII. PERONOSPORALES

Fam. 1. Pythiaceae
Zoöphagus
Pythiomorpha
Pythiogeton
Pythium

F. K. SPARROW, JR.

A NEW SPECIES OF MYCETOZOA

Accompanied by Mr. Joseph H. Rispaud, I attended the Foray of the Mycological Society of America held at Macdonald College, Quebec, August 25–28, 1941. Macdonald College is situated at Ste Anne de Bellevue, on the Island of Montreal, nearly thirty miles west of the City of Montreal. On August 26, at Ste Dorothee on the Island of Jesus, which island is situated northwest of the Island of Montreal, and separated from it by the river La Prairie, we found a small development of about 25 sporangia of an unusual *Badhamia,* which, later in the laboratory of Macdonald College, was the subject of considerable interest. An effort was made to obtain other collections, and on the following day Mr. Rispaud succeeded in discovering another small fruiting on the campus of Macdonald College. On the morning of the last day of the Foray, August 28, at St. Martin, also on the Island of Jesus,

we made the third and best collection, more ample and representative. All three collections are alike, and on the bark of dead spruce twigs and sticks. Following the last excursion, the party proceeded to the Montreal Botanical Garden where a Laboratory of Plant Pathology was dedicated in honor of Dr. John Dearness, a veteran Canadian mycologist. This event closed a successful four-day foray of the Mycological Society of America.

The *Badhamia* appears to be an undescribed species of the Mycetozoa, and I have great pleasure in describing and naming it after Dr. John Dearness, a past President of the Society.

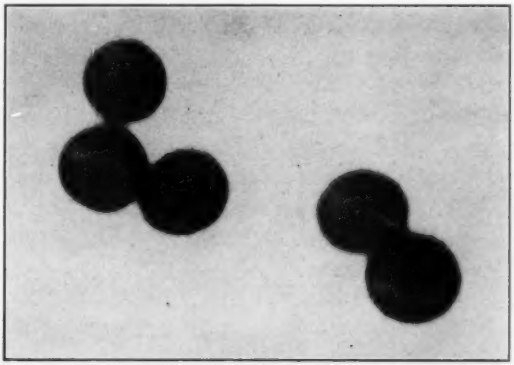


FIG. 1. Spores of *Badhamia Dearnessii* (× 1000).

Badhamia Dearnessii sp. nov.

Plasmodium incognitum; sporangia dissipata vel gregaria, in areis parvis, plerumque globosa, sessilia basibus angustis, subalba, 0.5–1 mm.; murus sporangiorum tenuis, membraneus, afferens granula calcis saepe amplificata, ubi calx deest exhibens colores iridis; capillitium reticulum calcis, album, in loculis aliquibus ubi calx deest admodum tenue et subhelvolum; sporae separatae, globosae, plene minute spinulosae, purpureo-fuscae, praeter cingulam pallidum angustum, 13–16 μ diam. Habitat super cortice Piceae albae mortuae.

Plasmodium? Sporangia scattered or loosely clustered in small developments, globose to subglobose, sessile on a narrow base, grayish white, 0.5–1 mm. diam.; sporangial wall membranous with deposits of white lime-granules often arranged to show veins or thickenings, iridescent when lime-less; capillitium a network of slender strands scantily charged with white lime-granules, the latter

sometimes absent when the capillitium is very delicate and may appear pale yellow in color; spores free, globose, minutely and closely spinulose over the entire surface, purplish brown with a narrow, pale area around the spores, 13–16 μ diam.

In some respects, *Badhamia Dearnessii* resembles several other sessile forms of *Badhamia,* but the spore characters, and particularly the pale bands, are diagnostic. The spore color is a little darker than usually understood as purplish brown. The occasional absence of lime in the capillitium does not alter its form or shape appreciably, except to make it frail and delicate. The pale yellow color observed may be the color of the thin membrane usually enclosing the lime-granules of the capillitium.

The third collection, N. Y. B. G. No. *2530,* is regarded as the type collection, and the specimen deposited in the Herbarium of the New York Botanical Garden is the type. Portions of the type collection have been distributed to the United States National Museum, the State University of Iowa, the Farlow Herbarium, the University of Toronto, the Montreal Botanical Garden, Macdonald College, and several students in Ontario. The other two collections, N. Y. B. G. Nos. *2512* and *2514,* are regarded as cotypes.—ROBERT HAGELSTEIN.